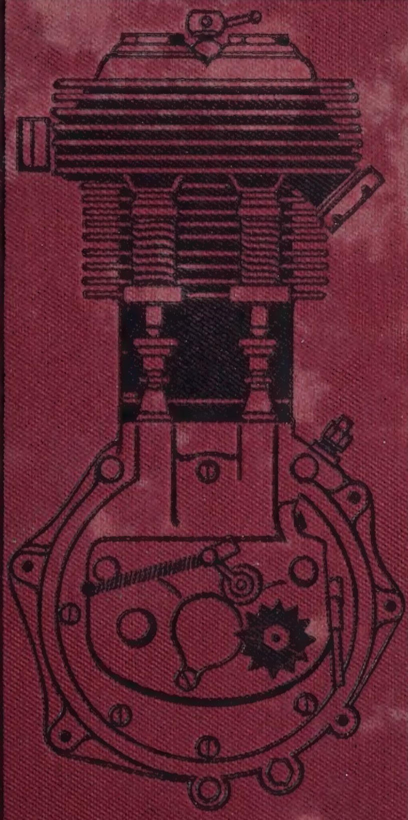
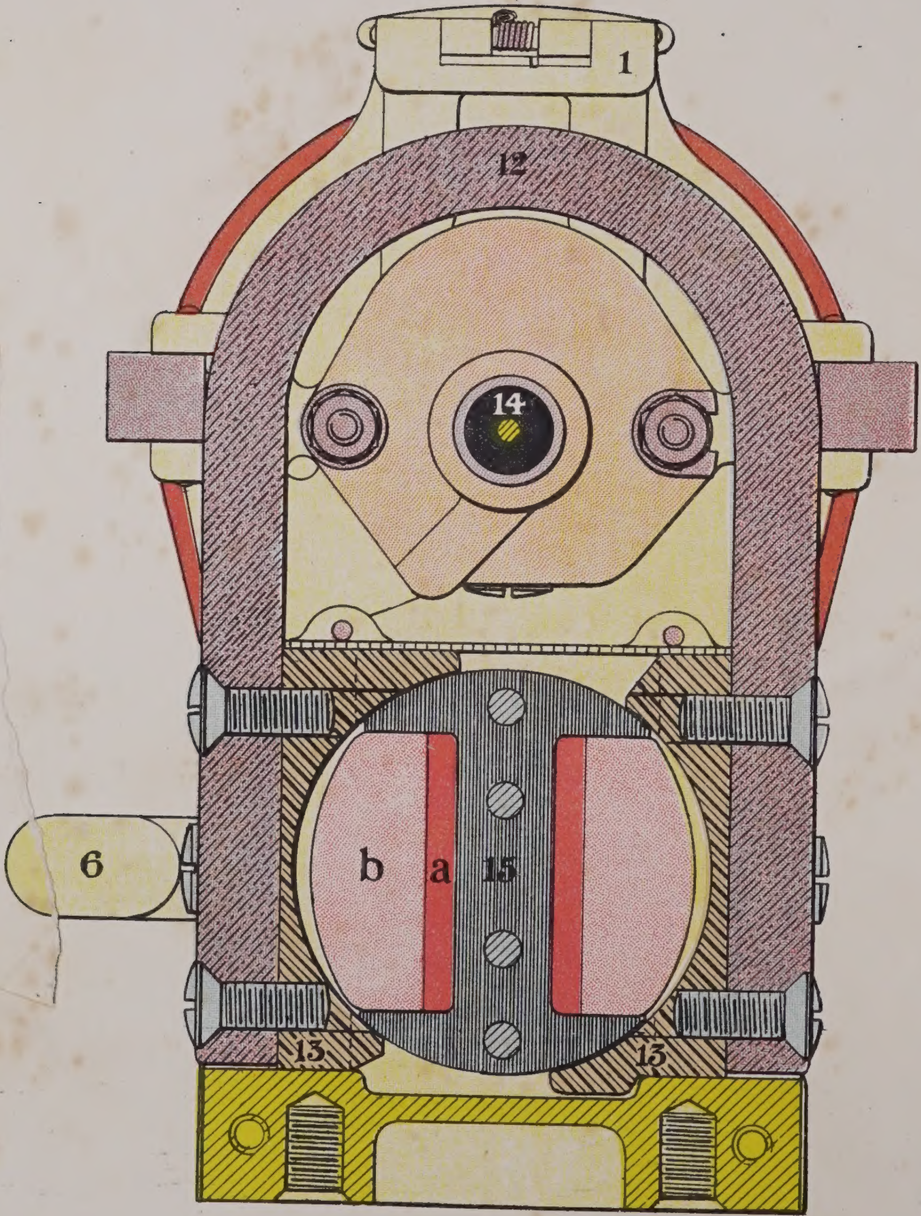
THE BOOK OF THE MOTOR CAR




1
12
14
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MODEL OF THE BLIC MAGNETO

DESIGNATION OF THE PARTS INDICATED BY NUMERALS

1. Oil Cover for Rear End Plate.
2. Dust Cover.
3. Front End Plate.
4. Fastening Screws for Plate.
5. Fastening Screws for End Cap.
6. Timing Lever.
7. Carbon Brush with Spring.
8. Carbon Holder.
9. Fastening Screws for Carbon Holder Flange.
10. Slip Ring.
11. Armature Spindle.
12. Steel Magnets.
13. Pole Shoes.
14. Rotary Distributor.
15. Armature Core.

a. Primary Winding.

b. Secondary Winding.

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THE MOTOR CAR

A COMPREHENSIVE AND AUTHORITATIVE GUIDE ON THE CARE, MANAGEMENT, MAINTENANCE, AND CONSTRUCTION OF THE MOTOR CAR AND MOTOR CYCLE

BY

RANKIN KENNEDY, C.E.

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"ELECTRICAL INSTALLATIONS," "STEAM TURBINES," "FIRST PRINCIPLES OF AEROPLANES," "FLYING MACHINES," "THE MODERN WORKSHOP," "MARINE PROPELLERS," "THE BOOK OF MODERN ENGINES," AND OTHER ENGINEERING WORKS

VOL. III

WITH OVER 250 ILLUSTRATIONS

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PREFACE TO VOL. III

THIS Volume deals first with the starting of motor car engines by compressed air and electrical energy. The starting of motor car engines of large size by hand is no easy work, and also gives rise to ignition difficulties at starting.

Electrical starting is quite practicable, electrical lighting is desirable, and electrical ignition is a necessity on motor cars. That being so, there can be small doubt that in time one dynamo electric machine with storage of electricity will be installed on cars, designed to perform all three functions, starting, lighting, and ignition.

The motor car has not yet reached the stage at which all machines arrive sooner or later, where inventors and designers begin to simplify designs; to reduce the machine to the smallest number of parts and these parts to the utmost simplicity.

The electric motor car is also dealt with in this Volume, as it has now become a practical success, due to the new alkaline nickel and steel accumulators now available for traction and propulsion work.

Small accessories of the engine and chassis are also referred to, together with apparatus and tools for repairs. The subjects of driving and handling cars, with instructions for their care and maintenance, are fully treated.

In conclusion some points in chassis and engine design are discussed, showing the present state of the art of designing motors and motor cars.

My thanks are due to the many manufacturing firms and their engineers for details of their latest designs and for photos, drawings, and blocks for illustrations.

Many young engineers feel that the motor vehicle has reached such a high state of perfection that there is small room for further improvements. But that feeling applies only to the present-day types which have become standards; there is still ample scope for inventive and designing ability

in the direction of new departures. The knowledge of what has been accomplished in the past, and the designs arrived at at present, such as may be gathered from these volumes, should form excellent guides to the motor engineers of to-day towards advancing the art of motor construction and their own advantage.

RANKIN KENNEDY.

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THE BOOK OF THE MOTOR CAR

VOL. III

THE CARE AND REPAIR OF MOTOR CARS. DRIVING. CONTROLLING. HANDLING

CHAPTER I

MOTOR STARTING

All internal combustion engines require to be started up in some way. The common and simple method is to turn the crank shaft round by a cranked handle; there is even in this simple operation a right and a wrong way. The wrong way is to face the engine and start with a downward push on the handle. Should a back fire occur, the handle will be thrown up and strain or break the wrist. The correct way is to stand with the right side towards the engine and rest the left hand on the dumb-iron to steady the body and give a rest against the pull, and start with the handle at its lowest position by an upward pull. Standing thus with the right side to the engine, the knees are well clear of the handle, and should a back fire occur the handle will be pulled out of the hand.

Sometimes an engine can be started "on the switch"—that is, when one of the cylinders has an explosive charge retained. It is then necessary only to switch on the spark to start the engine. This, however, cannot always be relied upon.

The starting of small power engines by handle is easy enough, but larger engines sometimes require considerable exertion. The starting handle on the engine in its simplest form engages positively with the engine shaft when turned in the direction of engine running, and releases immediately the engine starts, by a simple clutch device or free wheel action. This works all right provided no back fire occurs. A back fire turns the engine the wrong way suddenly, and as the handle then opposes the motion a violent shock may be given to the wrist and arm. Several devices have been brought out to obviate this danger;

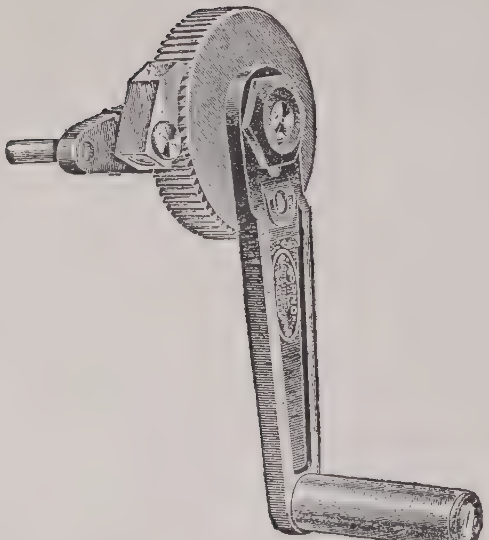


Fig. 1.—"Orno" Starting Handle, Large Power.

perhaps the best is that known as the "Orno," Figs. 1, 2, 3. The arrangement of the device is such that, whilst the starting handle can revolve the crank shaft in one direction, the crank shaft can revolve the handle in neither.

The complete affair is illustrated in Figs. 1 and 2, and consists outwardly of an ordinary starting handle, behind which is a metal drum, about 5 inches in diameter, on the outside periphery of which is cut a ratchet, the pawl engaging therewith being mounted on a short crank, which, to prevent it rotating, can be made fast in a convenient position to the front cross member, on which is mounted the usual starting handle bracket. The safety starting handle is simply substituted for the ordinary positive one, and for this purpose is provided with an adapter capable of fitting the starting handle shaft of any make of car.

Fig. 3 shows the component parts of the device in extended form, and the drawings in conjunction with the following description will no doubt make the working of the device quite clear. The principle is as follows: The starting handle itself is connected with a ratchet free-wheel in such a way that it can only be rotated by hand in the direction required to start the engine. As, however, it would be impracticable to attempt to avert the effect of a back fire by a simple free wheel arrangement—for this would either mean the breaking of the crank shaft or the carrying away of the ratchet—a clutch is introduced between the starting handle and the crank shaft, and is of a special type which allows of its automatic engagement when rotated in one direction only; a contrary rotation immediately effects its complete disengagement. This clutch is indicated at A in Fig. 3, the above-mentioned ratchet free wheel being composed of the outer drum B and the pawl C. The crank shaft extension terminates in a cup D, which is machined inside and out. The inside of it fits the clutch A, and the outside of it the ratchet drum B, A being keyed to B by means of two pins, whose secondary purpose will be presently described.

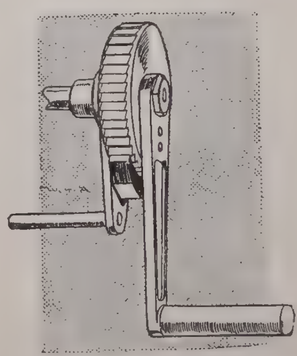


Fig. 2.—Small Power

The clutch A consists of a ring of cast iron, split as shown. It is made to be a fairly close fit inside the cup D, so that when it is contracted it runs freely inside the cup, and when expanded to a slight degree runs solid with it in one direction. As can be seen, the ends of the split ring carry pins which pass through the ratchet drum and engage with the starting handle. The drum can, by means of the ratchet handle, be rotated in a clockwise direction, and in these circumstances the starting handle causes the expansion of the clutch ring, as the former is mounted free on a spindle carried by the drum B, and hence the effect of the two holes which engage with the clutch pins is that of a toggle, which tends to open the clutch ring and force its periphery hard up against the inner walls of the cup D. Thus the mere fact of putting pressure upon the starting handle at once places the clutch in engagement with its outer cup, and the connection between the handle and the crank shaft becomes as positive as friction can make it. In the event of a back fire occurring, the cup D, which is for the moment solid with the starting handle, is restrained from moving along backwards by means of the ratchet; and also, since the lower pin of the clutch A is positively connected to the starting handle, this end of the clutch remains immovable. The upper pin, however, is given a certain amount of latitude in movement by means of the size of the hole in the drum B, through which it passes, and also by the drawn hole, as shown in the starting handle crank. Hence, although the near side of the clutch ring is fixed, the farther side can undergo a slight amount of movement. Since the back fire tends to rotate the cup D in an anti-clockwise direction, its tendency is also to rotate the clutch A in the same direction; but as soon as one end of the ring is fixed, this tendency applies only to the other end, i.e. that which carries the upper pin. This movement imparted to the ring has the immediate effect of causing it to contract, with the result that frictional contact ceases, and there is no longer any tendency for either the starting handle or the clutch ring to rotate with the engine.

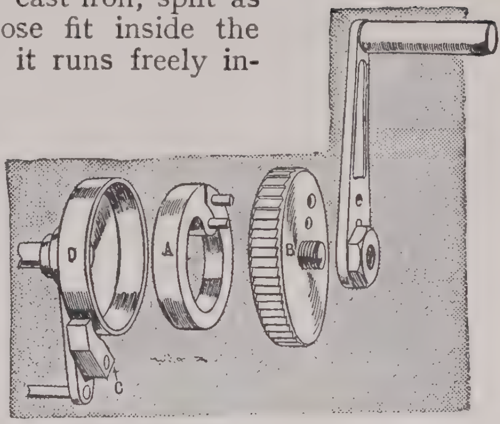


Fig. 3.—Details of Clutch and Handle.

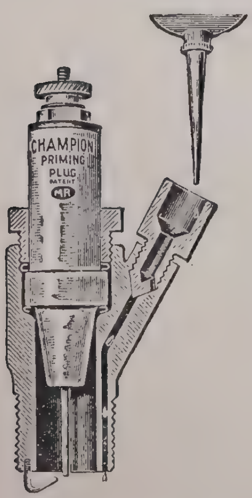


Fig. 3A.—Priming Plug.

A very good point connected with the device

is the elimination of small wearing parts. Every portion is of robust construction, and its effectiveness is not in the least lessened by its being kept lubricated. Thus there is no reason why it should occasion any noise whatever other than that produced by the ratchet when the engine is being started.

Aids to handle starting have been proposed. A simple one for priming the engine with petrol is offered in the shape of a new sparking plug (see Fig. 3A). The plug has a hole drilled through its side as shown, with a screw-down valve forming an oil cup at top. By screwing back the cup the passage in the plug opens at the face of the valve and petrol can be poured into the cylinder. On screwing down the cup the valve closes and the cylinder is ready for firing on the first compression stroke ending.

This plug may be useful also for other purposes.

We have now several systems for starting by power and compressed air, and electricity has been applied for starting.

The Wolseley system is a representative one of the compressed air type. The compressed air system has the advantage in that it can be used for inflating the tyres as well as for starting. A single stage air compressor pump is driven off the gear box lay shaft by chain belt as shown at A, Fig. 4, a diagram of the whole system.

B in Fig. 4 is the reservoir; C the distributor for supplying the cylinders; E the dash-board control mechanism; D is the valve and junction box.

Generally the compressor is designed to work at 300 lb. per square inch, and the reservoir can be charged with air at this pressure during a run of ten miles, but the engine, when warm, may be started with air of 60 lb. pressure, although it is preferable to provide a minimum of 100 lb. pressure. When the reservoir is full at 300 lb. pressure, the supply is sufficient to start the engine fifty times. As soon as the gauge shows that the pressure in the reservoir has attained this degree the compressor clutch on the gear box lay shaft should be disconnected; but in any case the compressor is so designed that an abnormal pressure cannot be developed; therefore no trouble need be feared if it should be left running. In connection with the inflation of the tyres, even if the pressure is insufficient the compressor itself can be run directly to inflate the tyres. It will be understood, of course, that once the reservoir is charged the air can be retained for any length of period, over night or for days. The main stop valve, which is combined with the junction box for controlling the inlet of air to the reservoir, is arranged to seal the reservoir when the car is not in use. It may be added, too, that air can be used for any other suitable purpose, notably for working a pneumatic jack to lift the car prior to the inflation of the tyres.

Turning now to the details of this air self-starter and tyre inflater, the compressor itself is illustrated in Figs. 5 and 6. It is of the two-cylinder type, driven through a clutch and enclosed silent chain off the

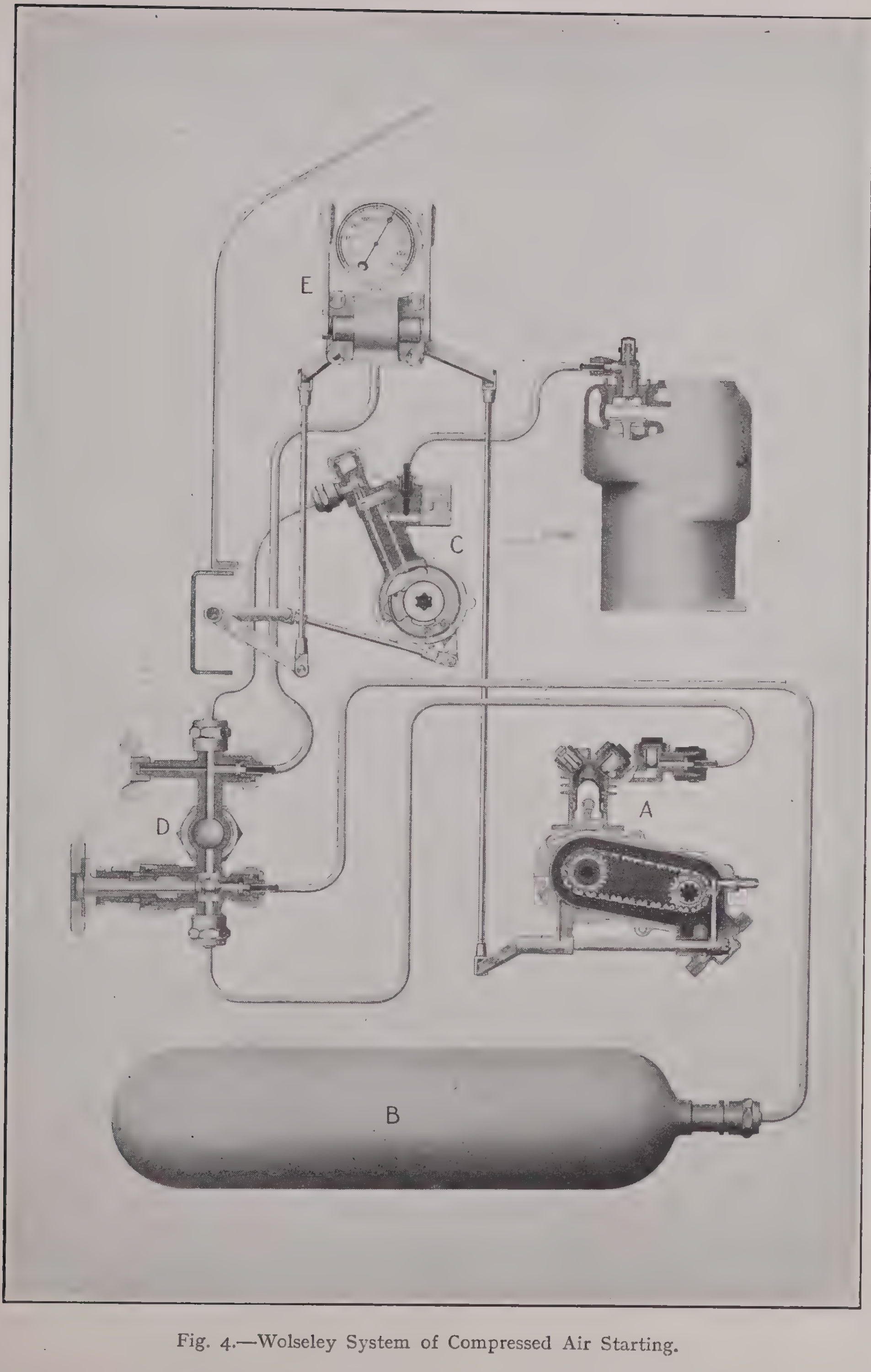
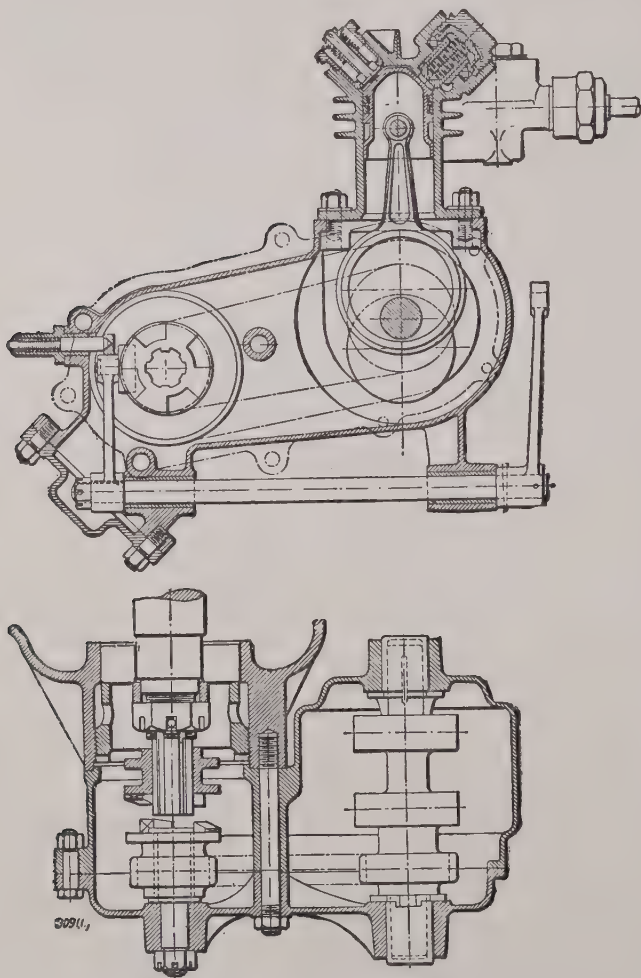


Fig. 4.—Wolseley System of Compressed Air Starting.

forward end of the gear box lay shaft, as shown on the plan of the chassis, and in detail in Figs. 5 and 6. The clutch is controlled by a lever on the dashboard, so that it may be thrown out of gear when the stored air in the reservoir has reached the desired pressure. The lubrication of the compressor is automatic in conjunction with the gear box lubrication. The reservoir is of forged steel, and is carried in the same way as an exhaust silencer on the under side of the frame.



Figs. 5 and 6.—Air Compressor for Self-Starter.

The distributor, which is illustrated in Figs. 8 to 11, is placed on the forward end of the engine, as shown in the end view of the engine, Fig. 7. The cams of the distributor are driven by the engine cam shaft, being mounted on the forward end of it. The distributor contains an air admission valve with double seal, and separate distribution valves, one for each cylinder of the engine, with the necessary pipes for communication from the central distributor to the valves on each cylinder. No parts of the distributor are in action except when the motor is being started up by compressed air. In such event the starting lever on the dashboard throws tappet levers into position between the starting cams and the valve stems, Figs. 10 and 11, and by a combination of the same motion opens the main air admission valve to the distributor, when the engine works as a compressed air motor. The change over to petrol is automatic, the air supply being cut off by the pressure of the explosions as soon as they occur. The tappet levers are moved clear of the starting valve stems and of the starting cams as soon as the engine is running on petrol. Automatic

check valves are provided in the pipes leading from the distributor to each working cylinder. The control mechanism on the dashboard consists of two levers and a pressure gauge, the levers operating the starting valve and the compressor clutch respectively.

The main stop valve, which is combined with a junction box, is provided on the side of the frame, so that the air reservoir may be sealed

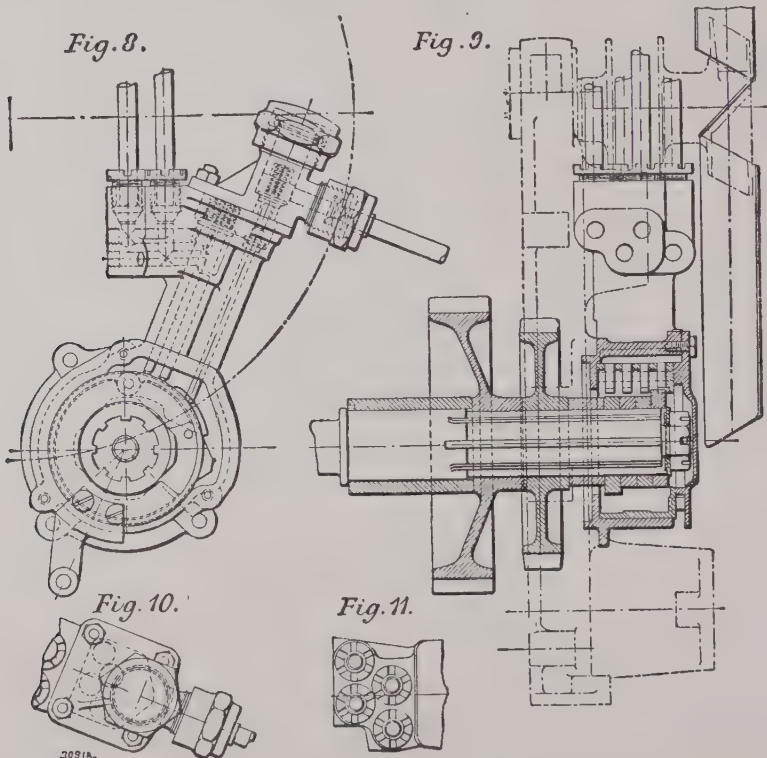
Fig. 7.—Distributor on Engine.

when the car is not in use to ensure retaining the compressed air for long periods. The only parts that can by their failure cause any difficulty whatever with the running of the car are the check valves on the cylinders.

These check valves are screwed into the valve covers with a thread which is the same size as for sparking plug, so that, in the unlikely event of irreparable failure of the self-starter, if these valves are removed

from the cylinders and ordinary sparking plugs put in their places, the car and engine will be restored to its normal state, as if no self-starter were fitted, the car being in perfect order simply minus the self-starter. As no part of the mechanism is in operation when the control levers are in a neutral position, no contingent damage or inconvenience can arise from the failure of any part of the mechanism.

As far as the actual working is concerned, the compressor may be left in gear all the time the car is running, as owing to its design it is impossible for it to compress to a greater maximum air pressure than



Figs. 8 to 11.—Details of Self-Starter.

approximately 300 lb. per square inch. The result is, when the pressure is low it puts air into the reservoir rapidly, and as the pressure rises so the rate of compressing falls. As the tank and fittings will all stand 900 lb. pressure, and each individual tank is tested to 600 lb. pressure, there is not the slightest danger of bursting.

It is, however, most desirable that the compressor should be thrown out of gear when sufficient pressure is obtained to avoid unnecessary wear and tear. The pressure should always be kept up fairly high, as the engine starts better with a high pressure ; whilst it also ensures that there will always be sufficient air available to inflate a tyre.

It will be found that the compressor is reasonably silent up to a pressure of 200 lb. per square inch, and beyond this the pulsation becomes increasingly noticeable as the pressure rises. Pressure should not in ordinary working be allowed to run above 250 lb. on the gauge, while 200 lb. will be found quite ample for ordinary running during the day

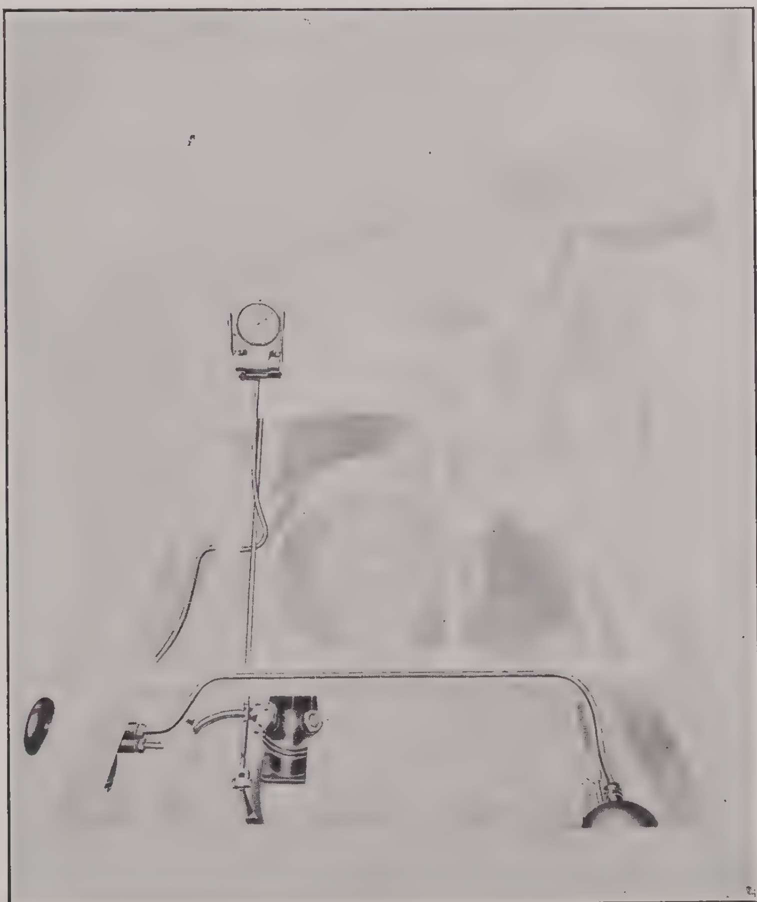


Fig. 12.—Connection of Parts of Starter.

—the higher pressure being necessary only when starting from cold in winter.

It will be found that a pressure of 200 to 250 lb. provides sufficient air to inflate one tyre with ample surplus for restarting.

Fig. 12 is a transparency photo showing the disposition of the various parts of the system on the car.

The Adams system is also a compressed air system. All compressed air systems are much alike, and differ only in the design of

details. In the Adams starter the feature is the improved starting and flat distributing valve in one casing.

Referring to the drawings, Figs. 13, 14, 15, 16, 17, wherein like letters of reference indicate corresponding parts in all figures, A A designates the cylinders of an internal combustion or explosion engine, B indicates an air compressor, C denotes an air reservoir for the storage of com-

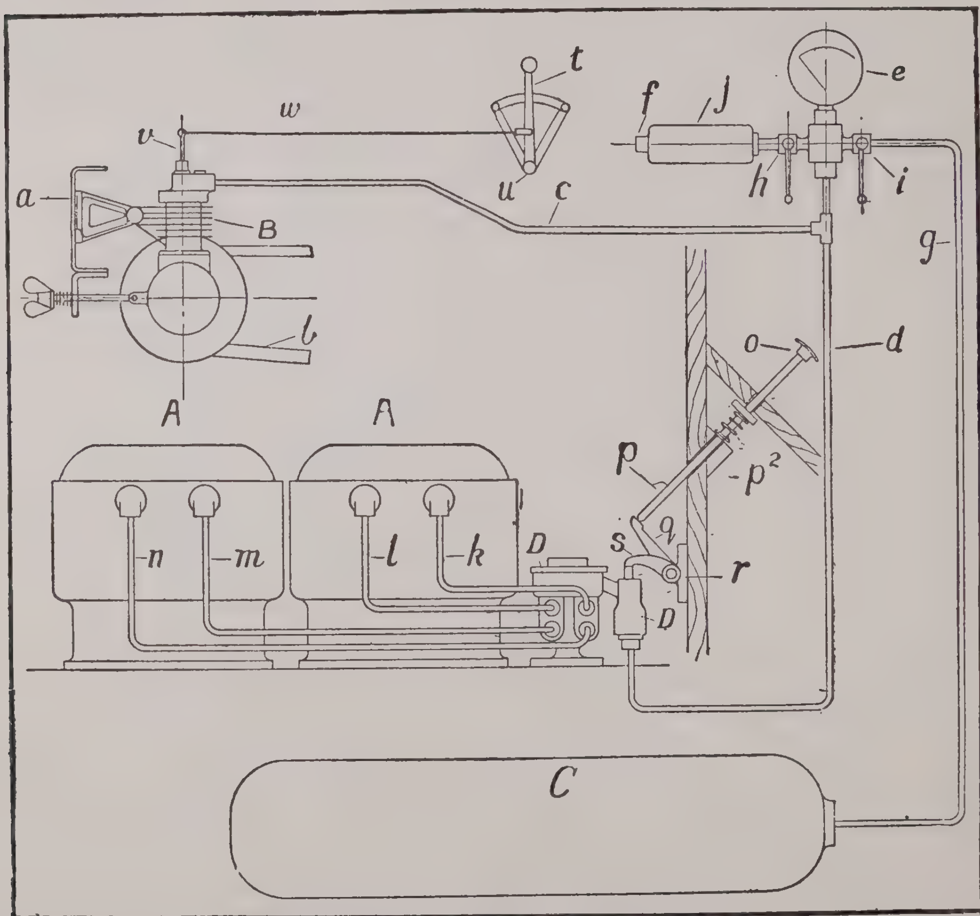


Fig. 13.—General Arrangement of Adams Starter.

pressed air, D an improved starting valve, operated by the driver, and combined with a distributor or distributing valve.

In Fig. 13 the air compressor B is pivotally mounted on any convenient member *a* of the chassis in a manner hereinafter to be described, and is driven from any available revolving member of the engine or transmission system. In order readily to adapt the compressor to an existing system, a belt *b* or other convenient known driving means may be employed. The compressor B delivers air at a suitable pressure into

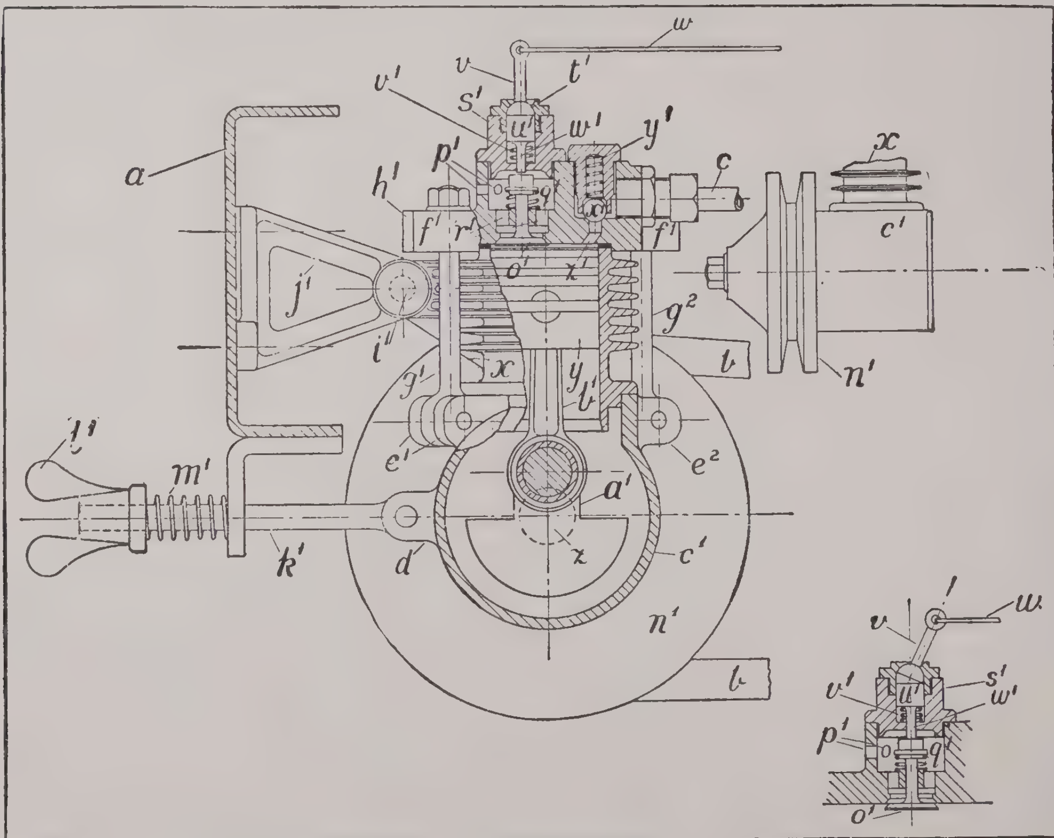
a pipe *c*, which is in communication with a pipe *d* connected at one point with the starting valve D and at another point with the pressure gauge or indicator *e* and also with the outlet *f* and pipe *g* through the stop valves or cocks *h* and *i* respectively. The pipe *g* communicates with the air reservoir C, which may be charged with air under pressure by opening the cock *i*, the said cock *i* being thereafter closed to maintain the reservoir in a charged condition when the compressor B is inoperative. In an alternative construction, the stop cock *i* may be arranged with a multiple of ways to control the air pipes *c*, *d*, *g*, and *j*, and may be actuated by the means adopted for operating the unloading valve of the air compressor. A convenient system of pipes may be connected to the outlet *f* for inflating tyres, blowing the horn, operating a forced gas or fuel feed to the engine, or other purposes. A strainer *j* may be used to supply clean air for the said purposes, and alternatively a pressure reducing valve may suitably be arranged either in conjunction with or separate from the said strainer *j* to reduce the air pressure as required. The air cocks *h*, *i*, may be combined in a two-way or multiple-way cock of known construction, and operated by a single handle to perform the various functions of the separate cocks in order to charge or discharge the reservoir as required. Communication between the improved starting and distributing valve D and the separate cylinders of the engine A is provided by means of pipes or tubes, *k*, *l*, *m*, *n*, in a manner to be hereinafter described.

A foot pedal O carried on a pedal column *p* is adapted to be depressed against the action of a spring p^2, to operate the crank *q*, roller bar *r*, and crank *s*, to open the starting valve. In the operation of the device in order to start the engine from rest, compressed air is delivered from the reservoir C through the pipe *g*, air cock *i*, and pipe *d* to the combined starting valve and distributor D. The pedal O being depressed, air is admitted to the cylinders of the engine A, through pipes *k*, *l*, *m*, and *n*, in the correct order of firing. Air is admitted to each cylinder during the explosion stroke, and the engine is driven as a compressed air motor until normal firing and running commence.

When the engine is running normally, the reservoir C is charged with compressed air from the compressor B through pipes *c* and *d*, cock *i* and pipe *g*. The lever *t*, which is pivoted at *u*, is adapted to operate the lever *v* of the unloading valve of the air compressor B by means of the coupling or wire *w* as will be described hereafter. The starting valve may alternatively be operated manually by a suitable handle or lever, operated from the dashboard of the car or other equivalent position, or this operation may conveniently be performed by actuating the means controlling a multiple-way stop cock *i*.

In Fig. 14 the air compressor B consists of a cylinder *x*, in which works a piston *y*, the said piston being driven from the crank shaft *z* through a crank a^1 and connecting rod b^1. In the example to be described the crank case c^1 is formed with lugs d^1, e^1, and e^2. The cylinder

cover f^1 and crank case c^1 are adapted to register with the cylinder casting x and in the preferred construction the separate units may be bolted together by means of eyebolts g^1 and g^2, which are pivoted in lugs e^1, e^2 on the crank case, and which engage in slots h^1 in the cylinder cover. Other methods of construction may be used in lieu of the preferred form described. The compressor is pivotally supported at i^1 on a bracket j^1 which is attached to any convenient support as desired. In a self-propelled vehicle the support a may be the side frame or other portion

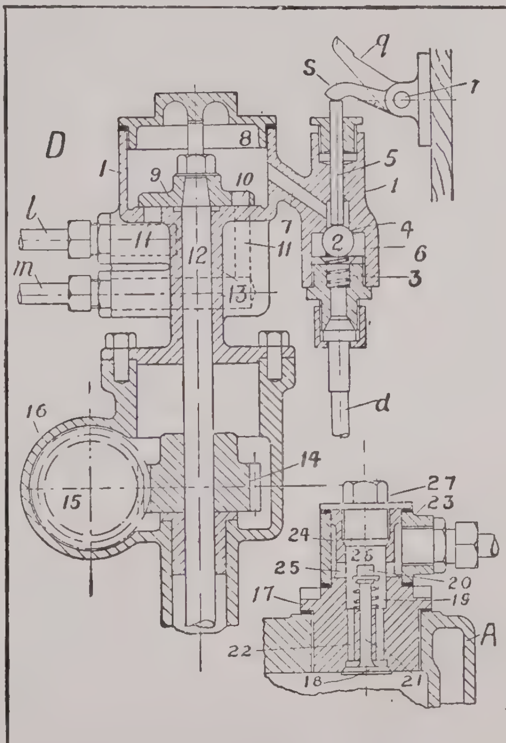


Figs. 14 and 15.—Air Compressor, Adams Car.

of the chassis. An adjusting bolt k^1, pivoted in lugs d, and a wing nut l^1 are adapted to adjust the tension of the driving belt b and the cushioning spring m^1 is adapted to take up the tension in a manner well known in the art, and which has been applied to the driving of the lighting dynamos of railway coaches. The belt pulley n^1 is preferably arranged with a V groove, more clearly shown in Fig. 14. The compressor may be driven from any available rotating member of the engine or transmission system.

In the cylinder head or cover f^1 of the air compressor B, Figs. 14 and 15,

is arranged an inlet valve O^1 of known form, air being admitted by holes p^1 to a chamber q^1 and thence passing to the cylinder by the ports r^1 and valve o^1. In the valve cover s^1 is arranged means for unloading the compressor to make same inoperative when not required, the said means consisting of a rocking lever v working in a spherical seating t^1 and adapted to depress a piston u^1 when tension is put on the wire or other coupler w. The piston u^1 is normally maintained in its uppermost position, and the rocking lever v is maintained in a vertical position, by the upward pressure of spring v^1. When the piston u^1 is depressed, to operate the unloading valve, as shown in Fig. 15, the stem w^1 of the piston u^1 engages with the stem of the inlet valve o^1, and air may freely pass into and out of the cylinder without compression. The exhaust valve of the compressor is of the non-return type, and preferably consists of a ball x^1 pressed on a spherical seating in the cylinder cover f^1 by a spring y^1. In operation, the compressor normally exhausts through the port x^1, into the pipe c, but if the compressor is inoperative the exhaust valve is maintained closed by the combined action of the spring y^1 and the pressure of air in pipe c.



Figs. 16 and 17.—Details of Starting Gear.

The construction and operation of the combined starting valve and rotary flat distributing valve will now be described with reference to Figs. 16 and 17. The said valves are assembled in a combined casing I, formed of a single casting, and this is advantageous to simplify the arrangement of piping and also to adapt the self-starting device to any engine without alteration to the construction of the said engine. The starting valve consists of a ball 2, pressed by a spring 3, on to a spherical seating 4. A pin 5, when engaged by the crank *s*, is adapted to depress the ball 2, to allow compressed air to pass from pipe *d* through chamber 6 and the valve to port 7 and thence into the distributing valve chamber 8. The rotary distributing valve consists substantially of a flat valve plate 9, in which are one or more holes or ports, 10, adapted to be rotated over a number of ports 11, corresponding to the number of cylinders of the

engine. The proportions of the valve opening 10 and its disposition with regard to the ports 11 are arranged so as to admit air from the chamber 8 to the ports 11, and thence to pipes *k*, *l*, *m*, *n*, leading to the engine cylinders, during the explosion stroke in each cylinder in the correct order of firing. The distributing valve plate 9 is secured to and is driven by a spindle 12, which has a bearing in the portion 13 of the valve casing 1. The spindle 12 and valve 9 may be positively driven from the engine cam shaft or other positively driven member of the engine rotating at one-half engine speed in the case of a four-cycle engine, or at engine speed in the case of a two-stroke engine. Alternatively, if the valve is driven at one-half engine speed in the case of a two-stroke engine, two holes 10 may be provided in the rotating valve plate 9. The number of holes in any instance would in practice depend upon the speed adopted for the distributor valve and on the actual firing conditions of the engine. In the drawing Figs. 16 and 18 the spindle 12 carries a worm wheel 14, and this is engaged by a worm 15, on the engine cam shaft, the worm gear being enclosed and protected by gear box.

The engine of the Adams car is shown in part section in Fig. 18, side elevation; the flat valve and starting valve may be seen at the head of the column at the flywheel end.

In Figs. 19 and 20 are shown the starting pedal on the dashboard, in Fig. 19 in side elevation and in Fig. 20 in plan, and in Fig. 20 the air pipes from the distribution valve are shown connecting to the non-return inlet valve of the cylinder.

The compressed air plant is of less weight than that of the electric starter; but the electric starter can be used for lighting and ignition; both have their advantages and disadvantages, actual practice and experience alone will decide between them.

The electric system is in use on the American Cadillac cars. We have already shown dynamos driven on cars for electric lighting of the car, and pointed out that a small electric plant, consisting of the dynamo, an accumulator, and regulating appliances, could be used to serve three purposes—starting the car, lighting the car, and for ignition.

There is no reason why this should not be put into practice, except that most cars have now magneto ignition, and the bad reputation of accumulators acquired at a date when they were not properly used and little understood.

We will examine this proposition more closely from an engineering point of view. When coil and battery high tension ignition was common the battery was charged periodically at intervals of a few weeks, and there was no means—in fact, there are none yet—whereby it could be readily ascertained at any time how much or how little of the charge remained. They were often not sufficiently charged to begin with, consequently they became exhausted without giving any preliminary indications. This exhaustion caused bad ignition, and, moreover,

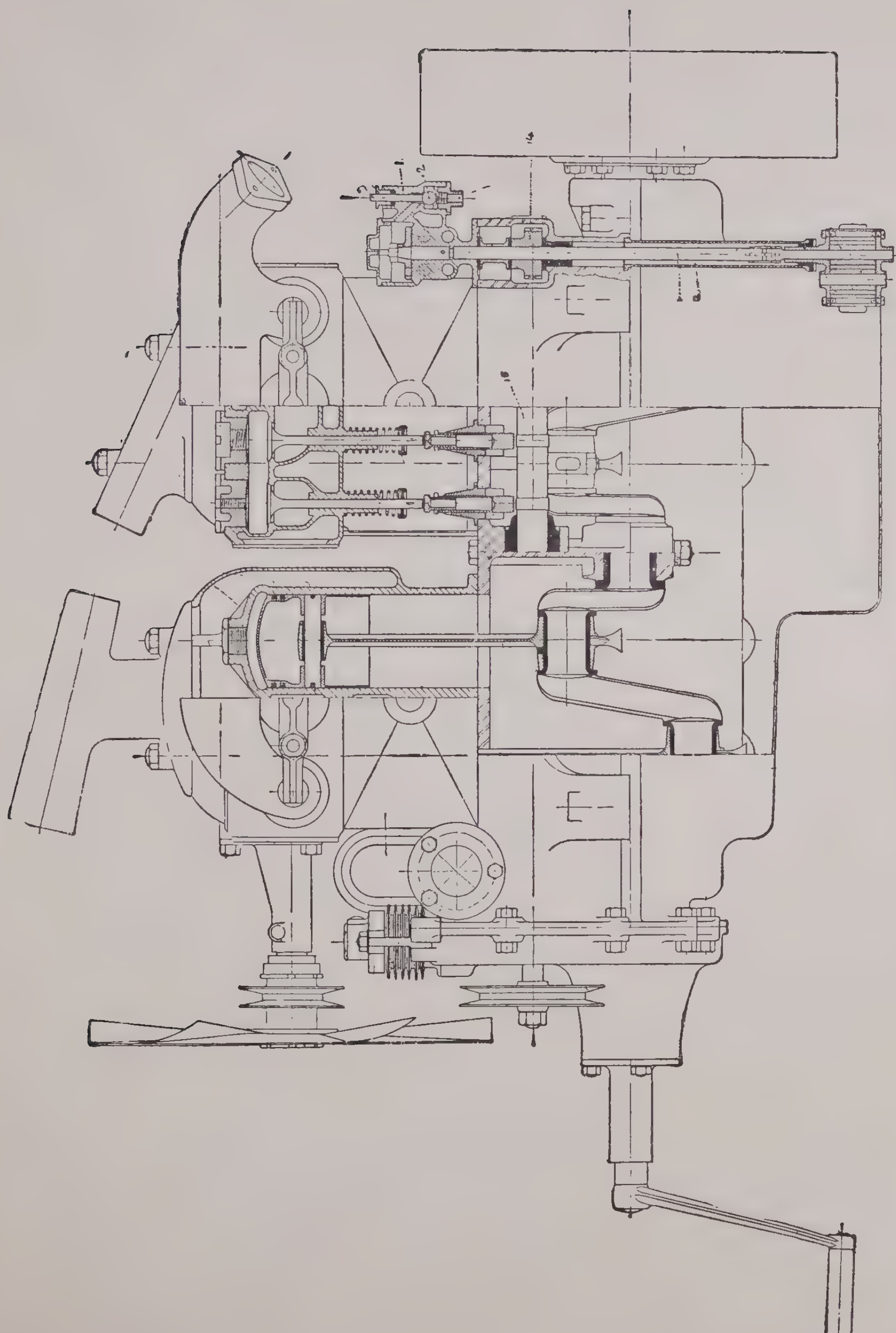
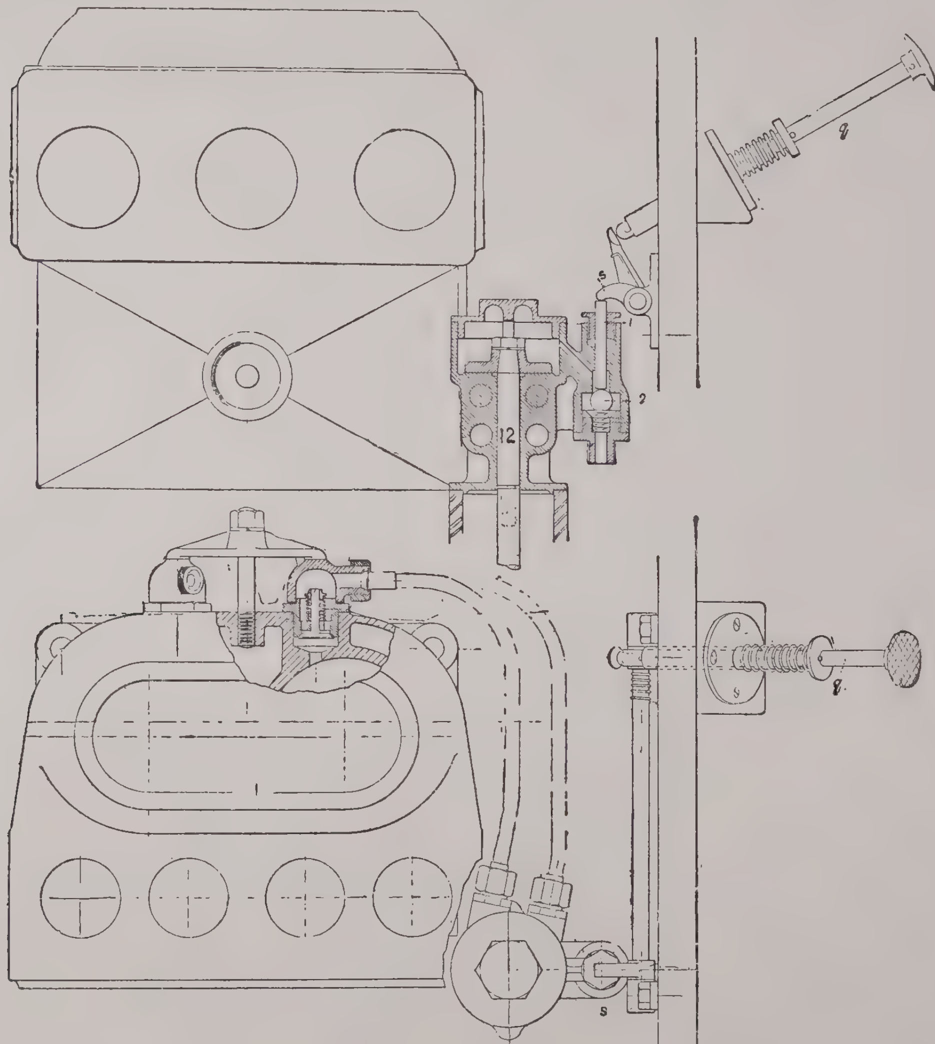


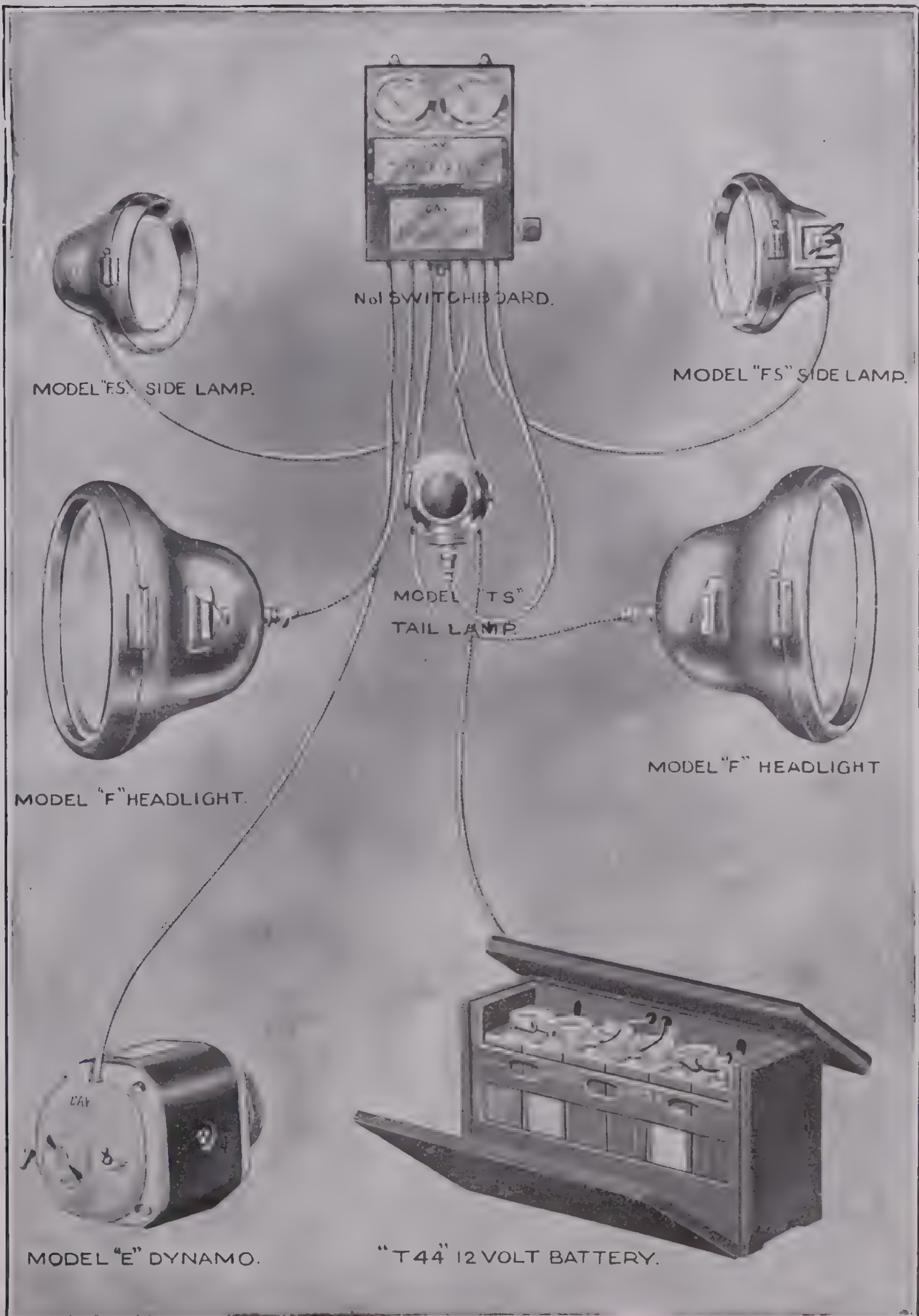
Fig. 18.—Part Section Adams Engine, showing Starting Gear.

spoiled the cells so that they went from bad to worse. No one would advocate the return to coil and accumulator ignition, for the conditions on a car are such as to cause trouble. But it is a very different proposition to take the ignition from a dynamo in combination with an



Figs. 19 and 20.—Adams Starting Gear.

accumulator. With such a combination, the accumulator is always charged without any attention given to it by any one, and current is drawn from it only for starting up, and for ignition and lighting only at slow speeds. Under normal running the dynamo operates the ignition and the lighting, so that the old difficulties with the accumulator do not arise.



Complete Car Electric Lighting System by Dynamo and Accumulator. Free Wheel Armature.

Another idea prevails that for these purposes a very large accumulator is necessary. This is not so, an 80 ampere hour accumulator is quite sufficient. Another point, Edison's new accumulator will stand very heavy discharges for a short time without injury; for starting purposes that is what is wanted.

In the electric system the dynamo is geared by a pinion on to the flywheel, which has teeth cut on its periphery for the purpose. The dynamo is shunt wound, and is shown in Fig. 21, M, geared to flywheel W; the lamps A A are connected in parallel. The accumulator B B is connected across the mains + and −, and so is the ignition F. S^1 is an automatic cut out which cuts off the connections to the dynamo when the speed falls too low to give an electromotive greater than the back electromotive force of the battery. When the speed is so low

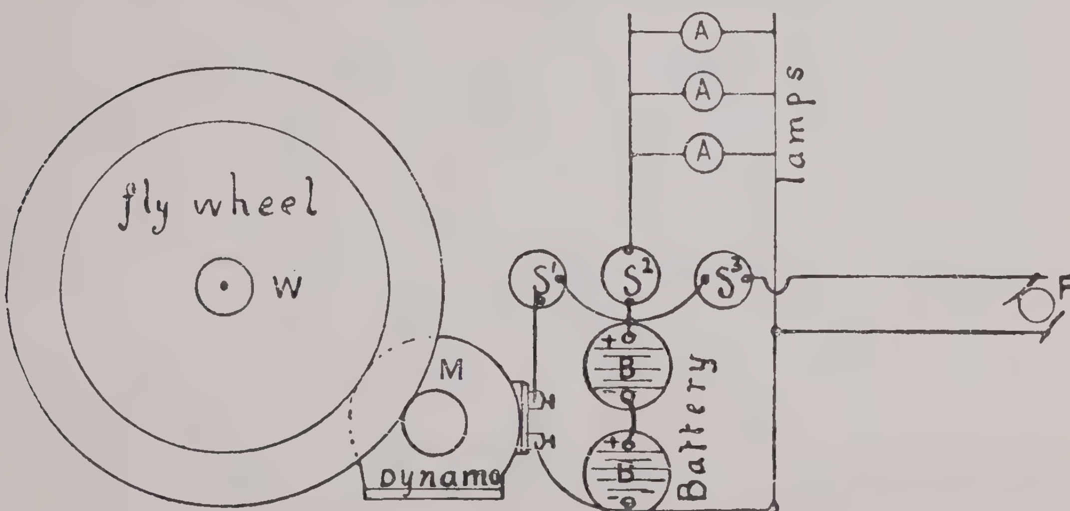


Fig. 21.—Diagram of System for Electric Starting and Lighting.

the battery would discharge back through the dynamo and run it as a motor driving the engine, and so waste the battery charge. The automatic cut out C prevents this action. If, then, when the engine is to be started up from rest we close the switch S^1 by hand, the accumulator will discharge back through the dynamo and start the engine by turning as a motor, and immediately the engine speed arrives at the point where the dynamo electromotive force overpowers that of the accumulators current will run into the accumulators and charge them. Another hand switch S^2 is connected to cut out the lamps when not required, and another switch S^3 may be added to cut off the ignition circuit through coils and timing contact maker F.

This sketch, Fig. 21, is only a diagram showing the connections. Of course some device such as we have already described in conjunction

with the electric lighting of the car will be necessary to prevent the dynamo electromotive force from rising to a high value at high speeds.

An electric lighting system which very well could be adapted to the three purposes is the C.A.V. system, which we here describe and illustrate.

The C.A.V. dynamo car lighting system has many novel points of value and interest. By the ingenious use of the magnetic action and reaction which occurs between the armature and field magnets, the output is kept absolutely constant at all speeds of the engine. Now, it is a well-known fact that if a dynamo be run as a motor, and supplied with current from an accumulator, the current taken will be proportionate to the load. In the case of such a machine being connected by chain or gear to an engine, it will naturally try to revolve the latter and the current taken will be excessive. This, then, is one of the problems that the inventors had to face in doing away with every form of automatic cut out, but a problem which they have admirably succeeded in solving.

In the C.A.V. dynamo a simple free wheel is interposed between the pulley and the armature spindle, so that when the engine is stopped, or run too slowly for the dynamo to charge the accumulators, the armature can revolve freely or "motorise," thus overrunning the driving pulley. Owing to the design of this machine, only an exceptionally small current is taken from the battery. With this free wheel device it is impossible for an excessive current to be discharged from the battery through the dynamo, and owing to the extremely low speed at which these dynamos generate, the free wheel only comes into action when the engine is actually stopped.

One of the great advantages of the free wheel over the cut out system is the fact that there are no extra contacts which are liable to get out of order, and the dynamo charges immediately the voltage rises above the battery voltage. With a cut out the dynamo voltage rises very considerably before it "cuts in" and relies on a reverse current and a spring to "cut out." It might be thought that to allow the dynamo to take current from the accumulator at any time is wasteful—but a moment's reflection will show that quite the reverse is the case, for whereas an ordinary cut out is taking current through its shunt and series coils the whole of the time, with the C.A.V. free wheel system it only happens for a few moments occasionally; even then the consumption of current is infinitesimal.

A switch is provided to disconnect the dynamo when the engine is stopped. Should this be accidentally left on, the "buzzing" of the free wheel is sufficiently audible to attract the driver's attention. The convenience of being able to switch the dynamo out of action when the accumulators are fully charged is also worth noting, as in some systems this is impossible.

So far as pleasure cars are concerned, during the past two years, the advantages of the free wheel system over the cut out has been proved.

C.A.V. Electric Lighting System

In the early days of electrical engineering when lamps were run in series of forty to sixty in a row, a constant current dynamo with variable electromotive force was a desideratum. But in the case of lighting a motor car the problem is to obtain a constant electromotive force with a variable speed of driving the dynamo—quite another problem and one of great difficulty. But several designs have proved themselves capable of maintaining a fairly constant E.M.F. after the speed of the dynamo passes above a certain minimum limit. Below that limit no dynamo can remain at constant E.M.F.

Hence the necessity for the storage battery or "accumulator," which stores electricity when the engine is at high speed and supplies electricity when the engine is stopped or running below the limit.

When the minimum speed at which the dynamo can charge the battery is reached we must either cut off the connection between the dynamo and the battery, or otherwise prevent the current running back through the dynamo; this, as we have shown in Vol. I, p. 207, is done by automatic cut outs in several systems. In the C.A.V. system the current is allowed to run back through the dynamo and to drive its armature as a motor, but the quantity of current running back is checked down to a negligible quantity by the counter E.M.F. of the armature acting as a motor. The armature is driven by a free wheel, hence when it ceases to oppose any force to the drive the speed falls to the limit. It runs free on the shaft by a very small back current, just sufficient current to overcome the exceedingly small friction of the free armature.

This is a very pretty device and a highly rational one for preventing the discharge of the battery through the dynamo at slow engine speeds.

The second problem is to keep the E.M.F. constant at variable speeds above the limit and up to full speed. This was early accomplished in dynamo designs, by making the field magnets magnetically saturated at the low speed limit, and so proportioning the armature reaction on the field so that its demagnetising effect balances the increase of speed. E = E.M.F. is proportional to E = N.Z., wherein N is the number of revolutions of the armature per second, and Z the magnetic field strength. Hence, if N diminishes in the same ratio as Z increases, or vice versa, E will remain constant.

In some early dynamos so great was this armature reaction that the E.M.F. actually was less at higher than lower speeds, but by properly calculating the field strength and the armature reaction a very constant E.M.F. at all speeds above the limit where field excitation begins to fail can be obtained.

A characteristic curve is given of a C.A.V. dynamo in Fig. 22, wherein it will be seen that the current starts at 600 revolutions per minute, rapidly rising to a maximum at 1,400 revolutions, at which it gives 15 amperes current through the battery, and this current is maintained constant up to 4,000 revolutions per minute.

Now $C = \frac{E}{R}$, in which C is the amperes, E the voltage, and R the total electrical resistance. Now R is constant in charging a battery at constant current, hence E must be constant also.

From this curve we see that at 600 revolutions per minute the battery E.M.F. balances the dynamo E.M.F., and so there is no current flowing into the battery, the two E.M.F.'s being opposed. Hence, should the speed fall slightly below 600, the battery E.M.F. will overpower the dynamo E.M.F. and drive current back through the armature, causing it to run free in the same direction as when charging, but running faster than the driving pulley. The quantity of current

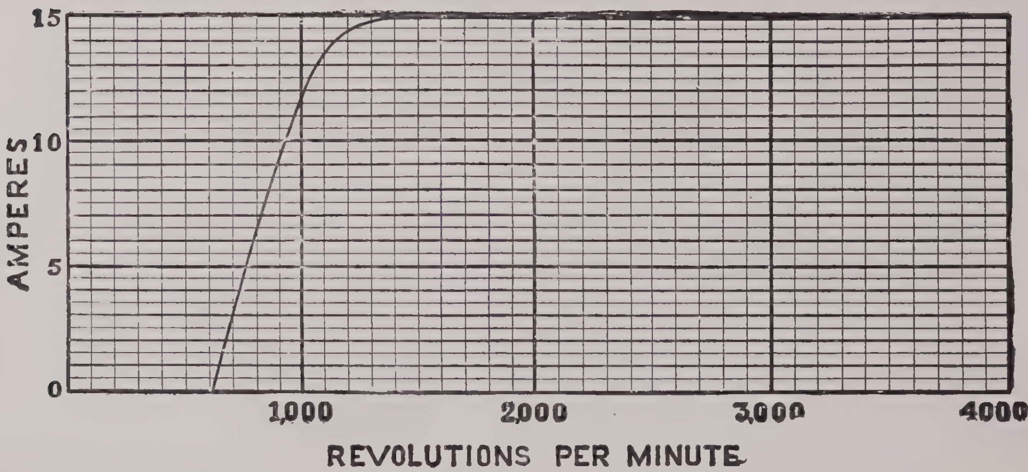


Fig. 22.

required to run the free armature might be as low as one ampere; it depends on the friction.

The following is a description of the dynamo.

In this machine, Fig. 23, there are two ordinary poles N.S. and two subsidiary poles N_1S_1. The former are excited by the windings which are supplied with current from the brushes of the machine.

The magnetic flux excited by these windings passes—when not distorted—diametrically through the armature from one pole N. to the other poles, and, dividing right and left, finds return paths through the frame of the machine as shown by thin dotted lines.

The two subsidiary poles have no winding upon them of any kind. Magnetism is excited in them by the reaction of the armature—not of the whole armature, but the reaction due to currents generated in certain short circuited coils, namely, the coils which are for the time being short circuited by the brushes that are collecting the current at the commutator. The position of these coils is shown by four black dots.

The operation of the machine is as follows: The brushes, being set

in the usual neutral position with respect to the ordinary poles N.S., the coils which they short-circuit in the act of commutation are the coils which for the time being are not in a neutral magnetic zone, as in the case of an ordinary dynamo, but are in an active zone where they are cutting the magnetic lines of the field due to the "subsidiary" poles N_1S_1. Hence, during the period of short circuit, they will be the seat of short circuit currents. These short circuit currents cross magnetise the armature and tend to set up a magnetic flux at right angles to the flux of the poles, and this cross magnetising effect is greatly augmented by the presence of unwound "subsidiary" poles.

The result is that the previously existing flux is distorted and, instead of traversing the armature diametrically from one subsidiary pole to the other, now turns aside, passing quadrantically through the armature, breaking up into two paths each of which includes one quarter of the frame. This change of path occurs gradually as the speed rises.

In addition to this short circuiting effect, there is the effect of the working current in the whole armature winding, which also sets up a magnetic field directly opposing the field of the subsidiary poles, thus reducing the initial flux, and since these demagnetising reactions increase with the speed they will counteract the tendency of the generated electromotive force to rise as the speed rises, so that the output remains constant.

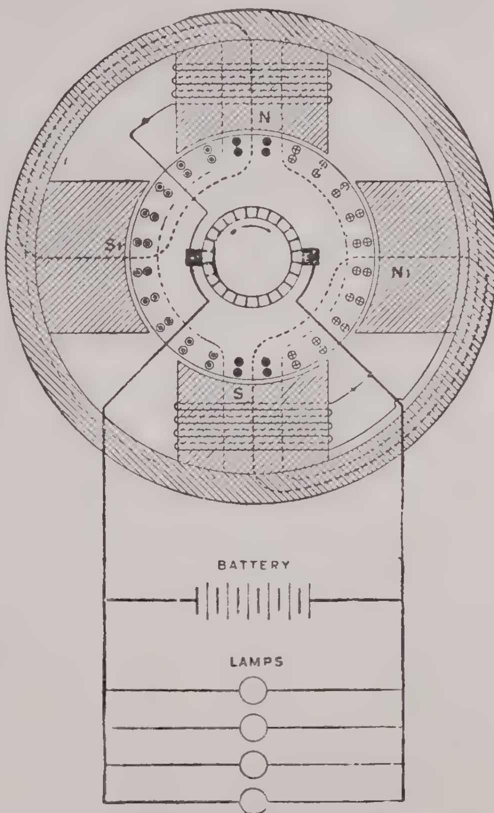


Fig. 23.—Diagram of the C.A.V. System.

The switchboard is shown in Fig. 24.

Owing to the fact that the dynamo supplies such a steady current over a great range of speed, it is only necessary to employ a comparatively small battery, which will be working under ideal conditions, and thus have a long life. The battery is shown in Fig. 25.

It is necessary that batteries of special design and construction be used.

The position in which the battery should be fixed is quite optional, but the footboard of the car is the most convenient and accessible one.

The outer or containing case can of course be painted to match the body of the car.

The two most popular sizes, i.e. "T.33" and "T.44" (12 volt) only are fitted with inner crates. These two sizes are therefore particularly suitable for lighting where a dynamo is not fitted, owing to the ease

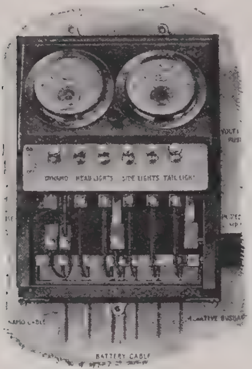


Fig. 24.—Switchboard.

Fig. 25.—Battery.

with which the batteries can be changed. The smaller sizes, being in one unit, do not require crates; while in the larger sizes crates are omitted in order to save space.

The armature of the dynamo is drum wound and driven as before mentioned by a free wheel. It is shown in Fig. 26 as removed from the machine. The brush gear is a good design, substantial and acces-

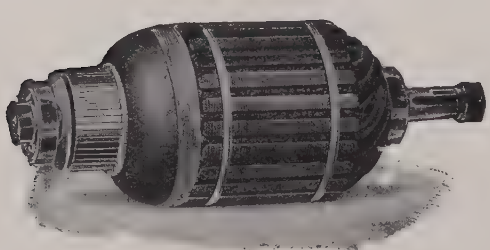


Fig. 26.—Armature.

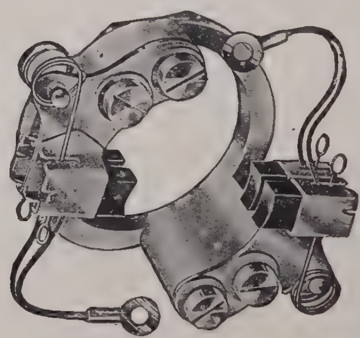


Fig. 27.—Brush Gear.

sible. It is shown in Fig. 27 apart from the machine and carrying two pair of carbon brushes. These brushes wear for many months without attention and then require only to be set forward to make up for wear.

The field magnet with its four poles is shown apart in Fig. 28 with the two exciting coils visible.

The dynamo is driven by chain belt, Fig. 29, having steel links faced on each side by leather links carried on steel pins.

The dynamo may be driven from the fan pulley on the crank shaft the clutch coupling, or clutch shaft, and for this purpose split pulleys are provided; one of which is shown in Fig. 30, for fitting to the clutch shaft. The complete machine is shown in Fig. 31.

Fig. 28.—Field Magnet.

Fig. 29.—Chain Belt.

If the dynamo is to be used for starting the car and for lighting as well, then the battery will require to be larger and the dynamo geared more substantially and positively to the engine. The battery probably

Fig. 30.

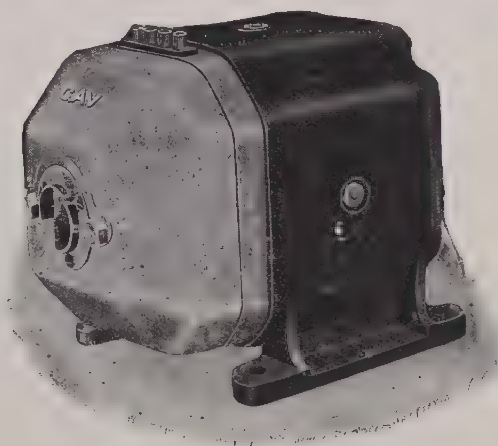


Fig. 31.—C.A.V. Dynamo.

would also then be better of Edison type so as to withstand heavy discharges for a brief period without damage.

Other systems of car lighting by dynamo and battery can, of course, be adapted also to starting and ignition purposes; but this free wheel

dynamo with its four-pole control seems to offer special advantages for performing the triple duties on cars, starting, ignition, lighting.

The question of the cost of starting and lighting a car by electricity has come up sometimes. It has sometimes been claimed by eager salesmen of the system that there is no expense in lighting a car by electricity, no carbide to buy for the lamps; that, however, is an obvious fallacy. The electric light takes power to produce it, from 1 to 1½ watts per candle power, and starting also takes power although only for a few seconds. As a matter of fact it has been deduced by some experiments that it takes on the particular car tested of 25 h.p. 10 per cent. of the fuel consumed for the lighting and starting.

In *The Motor Age* the trial is thus described:

"The car was a five-seated touring car, with 4 inch by 4½ inch cylinders, fitted with an electric lighting and starting set, of the type in which the motor generator armature forms the flywheel of the engine, and the tests consisted of two economy runs. A special one-gallon tank was fitted to the dashboard of the car, the main tank being disconnected and a carefully measured gallon—U.S. gallon—of petrol was put into the special tank. The head and tail lights were switched on and the car was started with the electric starter and run at 20 m.p.h. until the petrol was exhausted. The odometer at the end of that time gave a reading of 21·4 miles.

"This test was followed by a similar one, with all the same conditions with the exception that the wires leading to the regulator were disconnected, so that the generator was not supplying current to either the battery or the lights. The motor leads were connected to the battery sufficiently long to start the engine and then immediately disconnected, and the car ran out its fuel supply with a mileage showing of 23·6, giving a mileage increase of 2·2, when the electric outfit was not working.

"It may be mentioned that the lamp load in the first test included two 16 c.p. headlights and one 4 c.p. rear light of the ordinary tungsten type. The side lights were not used. The charging rate averaged 15 amperes, and the speed of the car varied from 19 to 23 m.p.h. Of course, the mileage without the electric equipment would probably have been greater had the dead weight of the electric equipment itself been removed, although it must not be forgotten, when considering this, that an acetylene outfit is not without weight, though that weight is quite small by comparison with the average electric outfit, and it is probable also that, in the first test, the mileage would have been less had a generator been used in which the armature was rotated by gearing connected up with the engine, instead of being incorporated in the flywheel."

There is something wrong here in this test. It is to be taken that the car did over 10 per cent. more distance with the lights cut off than it did with them on. Hence it is argued the lights consumed 10 per cent. of the power; but the electrician, when he finds power disappearing,

generally wants to know where it is going to waste and can trace its leakage. It is stated quite off-hand in the above extract that "it may be mentioned that the lamp load was two 16 c.p. lights and one 4 c.p. lamp. The side lights were not used" (why the side lights were not used is not stated).

Now the total c.p. was $2 \times 16 + 4 = 36$ c.p., at 1·5 watts per c.p., giving a total power for lighting equal to 54 watts, that is less than $\frac{1}{12}$ of a horse-power; and, assuming the electric plant to be about as bad in efficiency as it could be, say 50 per cent. only, the power actually expending in lighting could not possibly exceed $\frac{1}{6}$ horse-power, an amount somewhat less than 10 per cent. of 25 horse-power, and not easily measured in such a small quantity.

The fact is, these rough tests so often made by motorists are meaningless. The error is shown in the statement that the "charging rate of the battery averaged 15 amperes." So that besides lighting the car they were at the same time charging the batteries and crediting the whole electric power to two 16 c.p. lamps and one 4 c.p. lamp. These batteries take about 200 watts while charging, so that total load was $200 + 54 = 254$ watts or over $\frac{1}{3}$ of a horse-power electrically.

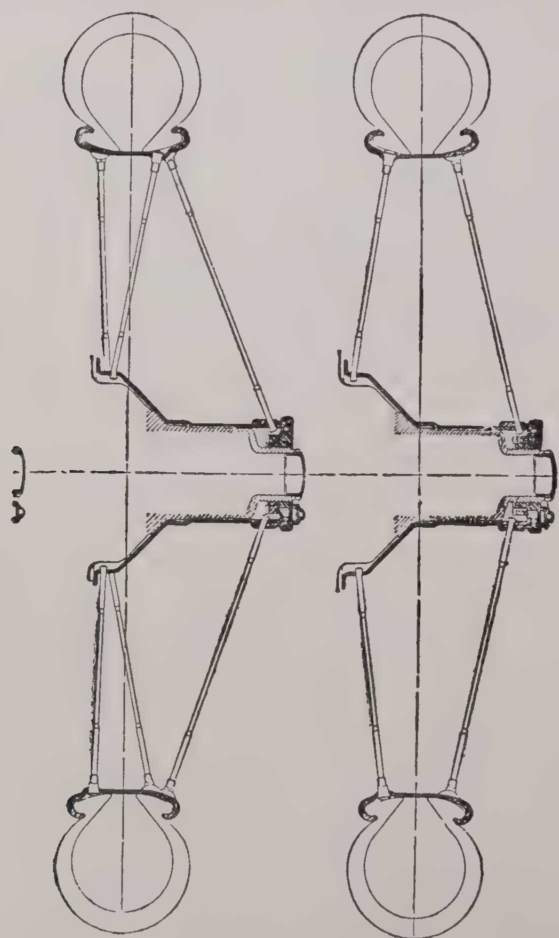
Electrical tests cannot be doubted if made properly, but when we find a rough test differs so much from the calculated results we must reject the results of the test as fallacious. Ten per cent. of 25 horse-power is 2·5. h.p., while even under the worst of circumstances and conditions the lamps and battery could not take more than 0·5 h.p. The difference is due no doubt to the rough nature of the test.

CHAPTER II

MOTOR CAR WHEELS AND SPRINGS, TYRES, AND ACCESSORIES

THERE are two classes of wheels in use on motor cars, wire wheels and wooden wheels, sometimes called artillery wheels.

The wheels are subjected to various stresses and impacts. The vertical stress due to the load acts as a compression stress on the wooden spokes, while it acts as a tensile stress on wire spokes. Both kinds of wheels are subject also to side stress due to centrifugal force in turning corners, also to the angle of the wheels and impact against the kerb or other road obstacles. Most of the stress in rounding a corner comes on the outer edge wheel.



Triple Spoke Wheel. Double Spoke Wheel.
Fig. 32.

Side stress may come upon either side of a wheel, hence the double spoke wheel Fig. 32 and the triple spoke wheels made specially to resist side stress, the triple spoke being the stronger of the two.

The wire wheel is in many respects superior to the artillery wheel, which, however, is cheaper. The artillery wheel has been much used. The wire wheel is preferable in most cases.

The Sankey pressed wheel is also worthy of attention. It is made up of two pressed steel stampings welded together. It may be heavier than the wood wheel, but for heavy work it is superior.

Another wheel, the Good-

year wheel, is made of sheet steel hard rolled, and is said to be lighter than either wood or wire wheels. The hard rolled steel is of course more resilient and stronger than mild steel, and can be used of thinner material.

As wheels are subject to damages, and the car thereby disabled, inventors at an early date devised detachable wheels, so that in the event of a wheel breaking down or being smashed, it could be quickly removed and a spare wheel refixed while on the road and without skilled assistance. But as tyres are often punctured while the wheel is intact, detachable tyres were brought out so that a spare tyre could be easily put on in place of a punctured or burst one. We may thus have a detachable wheel with a detachable tyre and so be prepared to replace a burst or punctured tyre, or a whole wheel if necessary may be replaced.

Fig. 33.—Rim for Wood Wheel.

We may now more particularly examine several makes of wheels and tyres. The number of wheels and tyres in use is so great that only a few of them can be noticed here.

The Stepney spare rim, carrying a pneumatic tyre, has suitable claw attachments, whereby it is gripped on to the beads of the rim of the punctured tyre by thumb screws or winged nuts. The punctured tyre is not touched; but allowed to remain until it can be attended to at a more convenient time. Fig. 33 shows the Stepney rim and tyre; only two winged nuts are necessary to fix it to the wheel rim. This tyre and rim is meant for wood wheels. A leather strap shown in the figure is for the purpose of strapping the rim to the wheel to prevent it from slipping round.

For wire wheels the rim is much the same, only no strap is used. A small lug is supplied for each wheel. This is riveted to the inside of the wheel as shown, Fig. 34, against one of the spokes. A forked clip fitted on the Stepney rim, as shown in Fig. 35, engages the lug in the car wheel and prevents the rim slipping or creeping.

Fig. 34.—Rim for Wire Wheel.

Fig. 36 shows the spare rim clamped to the wheel and lug and fork engaged.

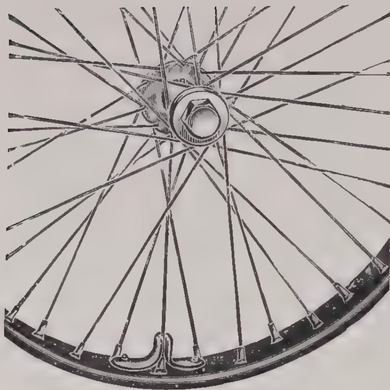


Fig. 35.—Forked Clips.

A flange attachment has also been devised for wooden wheels. This is a steel ring, Fig. 37, of a section shown in small figure. It is bolted by bolts passing through the wood rim as shown, and the hooks or claws of the spare rim are fastened into this flange, so that the damaged tyre need not be pushed in or touched at all.

By these simple means the motorist can quickly fix the spare rim and go on his journey without waiting to replace or repair a damaged tyre.

This, however, does not help him in case of a broken wheel. In this case only a detachable wheel is of use.

Another detachable rim for wheels may be referred to, as it is devised upon somewhat different lines, made by the Captain Tyre Company.

The sectional illustration, Fig. 38, clearly shows the general construction, which consists of an ordinary standard rim (which any standard tyre will fit) with a flange attached on one edge.

Around the wooden felloe of the wheel is shrunk (by a special process) a steel binding bond or band, which holds the wooden portion firmly together when the rim is dismounted.

This binding bond is arranged with a suitable step, which provides a seating of the same shape as the inner side of the tyre rim, and consequently forms a firm bearing surface, over nearly its entire width, for the detachable portion of the rim.

The rim is shown in the illustration fixed on the wheel, on which it fits very tightly.

It is held in position by the holding-on bolts (there are six to the larger wheels and four to the smaller), each of which passes through a hole in the wooden felloe, and engages with a gun-metal nut, or screwed boss, which is attached or fixed to the inner side of the road wheel. This nut

Fig. 36.—Rim Fixed.

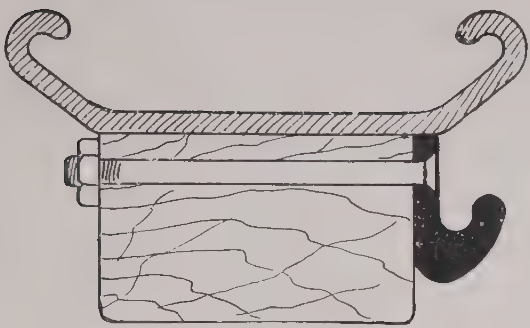


Fig. 37.—Flange Attachment.

or boss is recessed into the wooden felloe, which allows this holding-on bolt to engage with it before the rim is drawn into place on the wheel.

The flange on the rim has six (or four) holes, which agree with the holes in the wooden felloe, and through which the holding-on bolts pass.

Also, attached to the flange at the opposite side to the valve hole in the rim is a gun-metal boss with a hole through it and the flange, screwed the same size as the gun-metal nuts above referred to, and into which one of the holding-on bolts can be screwed.

It will be noted that the flange of the rim is drawn home tightly against the side of the felloes, thus consolidating the whole wheel.

A special form of security valve bolt, of patented design, is used, only one of which is required in each rim. As will be seen from the sectional illustration, it is arranged to be fitted through the valve hole, entirely encircling and protecting the tyre valve. No strain is thus thrown on the valve stem, which is left quite free.

This security valve bolt also serves as a guide or dowel, to register or coincide the holes in the flange of the rim with the corresponding holes in the wheel.

It also facilitates the fitting of the tyre to the rim.

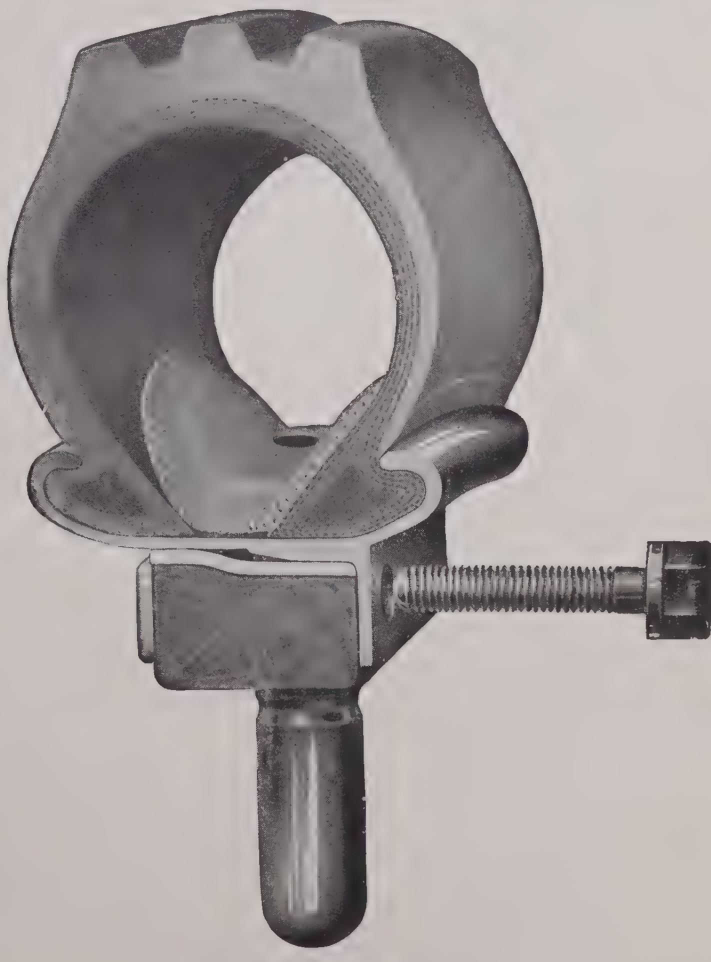


Fig. 38.—Detachable Rim and Valve.

In fixing the rim the wheel is rotated until the valve hole, which is somewhat larger than usual, is at the top.

The rim with the tyre fully inflated can then easily be hung in its place by first inserting the valve in the hole, which is shaped in such a manner that it allows the rim to be pushed into contact with the edge of the wheel all the way round.

The valve is protected by the extension of the security valve bolt, which also acts as a guide or dowel to correctly register the holes in the wheel.

The holding-on bolts are then inserted in the holes in the flange and wooden felloes and screwed into place, each one a certain portion at a time, with a special brace provided for the purpose, until the rim is drawn on the wheel, and the flange brought into contact with the side of the wooden felloe.

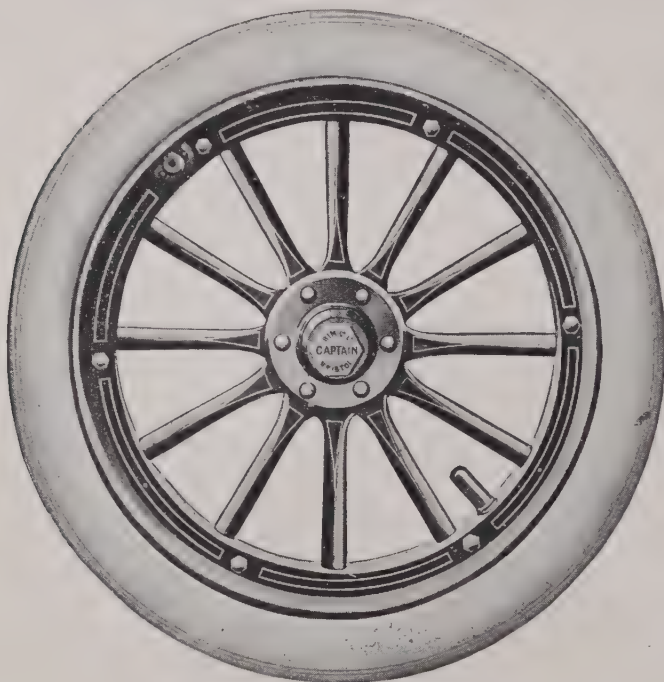


Fig 39.—Captain Wheel.

The rim is thus securely fixed and ready for use (see Fig. 39).

It is only necessary to screw these bolts up moderately tight, for there is no fear of their becoming loose with vibration or road shocks on account of the nut into which the bolt is screwed being fixed in the wooden felloe and so cannot turn round. When the bolt is tightened up, the portion of the wooden felloes between the nut and the flange of the rim is under compression, and thus acts in a similar manner as a spring washer.

The valve dust cap is of special construction, and is attached to the wooden felloe of the wheel, by means of a "push on" spring joint. It can easily be pulled off (no screwing is necessary) for the purpose of inflating the tyre, whilst the rim is attached to the wheel; but it is not necessary to remove the cap during the operation of attaching or detaching the rim.

In order to remove the rim (in event of a damaged or punctured tyre, or for the purpose of changing a plain tyre for a non-skid or vice

versa) the holding-on bolts are first removed by means of the operating brace.

The rim is still very firmly attached to the wheel, and enormous power is required to detach it.

This, however, can easily be done by screwing with the operating brace one of the holding-on bolts into the specially constructed boss illustrated above, attached to the flange of the rim until it comes into contact with a steel abutment plate fixed to the wooden felloe of the wheel, with the natural result that as the bolt is screwed against the abutment plate the rim is gradually forced off the wheel.

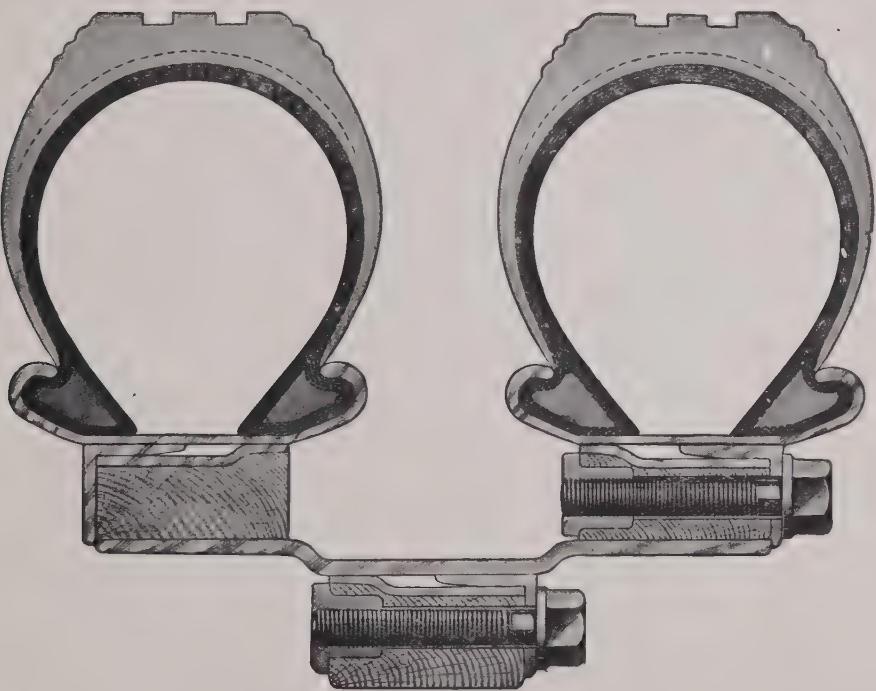


Fig. 40.—Twin Detachable Tyres.

The valve is immediately opposite the screwing-off boss, and the clearance allowed in the valve hole in the wooden felloe is sufficient to allow the rim to be then easily lifted off the wheel by hand.

The operating brace is the only tool required for attaching or detaching a rim.

Twin tyres, Fig. 40, are necessary for heavy vehicles, especially on the driving wheels. It is possible thereby to reduce the weight on each tyre to half.

The difference between using two tyres of comparatively small section on each wheel and one large tyre can only be appreciated by actual experience; and the increased mileage obtained from the former is invariably twice that of the large tyre.

The feature of the Captain twin rim is that both tyres may be dismounted conjointly or separately, and the wheel may be converted into a single rim (in a central plane with the wheel), as will be seen from the illustration Fig. 40.

The advantage of this will at once be apparent, for in the event of a series of punctures or bursts the twins can be converted to singles, giving two extra spare rims in addition to those carried in the ordinary way.

A divided rim, Fig. 41, has also been devised for facilitating the replacement of the damaged tyre. It has been introduced to meet the demands of the motorist who prefers fitting his tyres without having to strain them over the lips of the rim as in the case of the ordinary fixed type. In principle the divided form of Captain rim is precisely the same as the standard type, except that it has the additional feature of having the outside lip (or flange) detachable. The rim may therefore be either

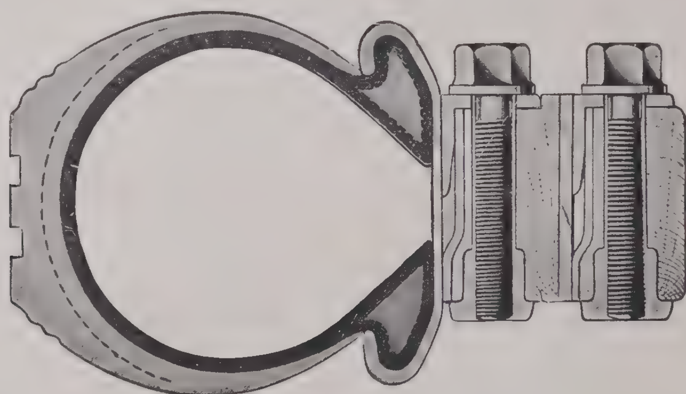


Fig. 41.—Divided Rim.

detached from the wheel without disturbing the tyre, or the outside flange only may be detached, enabling the tyre to be removed without detaching the body of the rim from the wheel. In this way, therefore, the divided type of rim may be used in the same manner as the other type of Captain rim, but should it be necessary to change cover or tube, the outside flange can then be detached.

To detach the rim *en bloc* (or without disturbing the tyre from the rim), remove the six holding-on bolts, and insert one of these bolts in the detaching boss shown on the opposite side to the valve hole, which easily forces the rim off the wheel. The wheel is then left entirely free, and can be fitted with spare rim, either the standard Captain type or the divisible type.

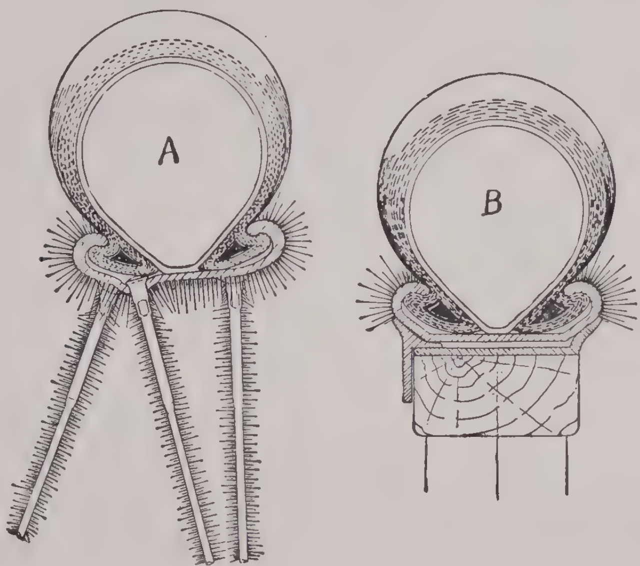
In order to attach the rim, rotate the wheel with the valve hole at the top, and then place the rim on the wheel by first inserting the valve in the hole, pushing the rim on by hand as far as possible into contact with the edge of the wheel all the way round. The holding-on bolts are then inserted in the holes in the flange and wooden felloes, and screwed

MOTOR CYCLE WITH SIDE CAR.

into place, each one a certain portion at a time, with a special brace provided for the purpose, until the rim is drawn on the wheel and the flange of the rim brought into contact with the side of the wooden felloe.

The rim is thus securely fixed, and ready for use. It is only necessary to screw these bolts up moderately tight.

The tyre may be fitted to the loose rim lying flat on the ground or whilst on the wheel. To detach the outside flange, remove the special nuts (which are easily discernible from the heads of the holding-on bolts) which will then leave one side of the rim entirely bare and ready to receive the tyre. It will be found advantageous to slightly inflate the tube and place it inside the cover, with the security valve bolt placed over the tyre valve before fitting to the rim. Should the cover be a new one, and somewhat stiff, a small tyre lever may be found necessary.



Wire Wheel. Wood Wheel Detachable Rim
Fig. 42.

The detachable wheel is considered by many to be a better spare to carry than a detachable rim. It was first patented by Mr. John Pugh in 1906 and is now known as the Rudge-Whitworth.

The arguments for the detachable wheel compared with the detachable tyre are given by the makers as follows: With a detachable rim there are two rims. A rim is not very heavy at any particular part, but it goes a long way round; an appreciable part of the rim cannot be cut away because it cannot be duplicated, therefore by duplicating the rim its weight is doubled. Again, by duplicating the rim you are adding the full weight of a single rim to the wheel at the very worst possible point, a point which is about twice as bad as adding the same amount of weight at the centre of the wheel. Where the rim fits there must be a joint. With a rim it is not only a joint of enormous length and of doubtful circularity, but it is in the zone that is swept by the mud splashes as a car goes along.

On the other hand, with a detachable wheel we duplicate merely the hub; the inner hub by reason of its bearings and other devices has got to be of a somewhat heavy design in any case, while the shell

to which the spokes from the rim are fastened in the case of the Rudge-Whitworth detachable wire wheel can be of relatively slender dimensions. Consequently, the weight added at the centre of the wheel is nothing like that of the original fixed hub; it is as a matter of fact only a few pounds, and these, which form the whole added weight of the detachable wheel system, are added at a position where it matters no more than if they were on the fixed axle itself.

It should be remembered that at that date, 1906, they had only theoretical facts to go upon. The facts were of course correct, but they had not been tried out and proved as has been done since. In these extensive trials many other facts have been brought to light. It has been found that the wire wheel can be made far stronger and far lighter than the wood wheel, and that the wire wheel possesses a resilience which is absent in the wood wheel. Further it will be remembered that all tyres become more or less heated in running. It is claimed for the wire wheel that owing to the conductivity of the rim and spoke this heat is quickly dissipated, whereas on a wood rim the tyre is insulated and heat cannot be easily carried off. In Fig. 42, A is a section of a wire wheel showing the radiation of heat from the rim and wire spokes, all being freely exposed. Besides the heat sent off by radiation, much is also carried off by the contact with the air. At B is shown the wood wheel, in which it will be seen that only the edges of the rim are exposed for radiation and air contact. There is no doubt of the cooler working of wire wheels.

Another argument in favour of a detachable wheel is that when it is off the car it is a perfectly rigid thing, and tyre fitting is quite easy, whereas with a detachable rim it has to be done very carefully on account of the flabbiness of the loose rim and the difficulties with the special kinds of security bolts that are made necessary.

The Rudge-Whitworth detachable wire wheel is described as follows:

The drawing Fig. 43 shows a section of a wheel in place on its inner hub; A is the inner hub, B is the detachable shell, and C is the lock nut. It is only necessary to put letters to these three parts, because they are the only three parts that belong to the device.

An examination of the drawing will show that the detachable shell B engages with the inner hub A by means of very long and numerous small flutes or serrations, giving a driving area of well over twice as much as in the earlier pattern wheels. Fig. 44 shows front view of the hub.

At the inner end the hub shell is supported on the inner hub by a cone seating of 60° angle, the area of which is 25 per cent. greater than the earlier pattern.

At the outer end is the lock nut C, which engages by means of its thread with the *outside* of the inner hub, and by means of an internal cone seating with the *outside* of the detachable wheel shell B. It will be noticed that there is nothing else that touches the lock nut, and it

will also be observed that the detachable wheel shell and the inner hub shell cannot rotate in relation to each other because of the fine engaging flutes or serrations.

It is obvious that when one article fits outside another it must be

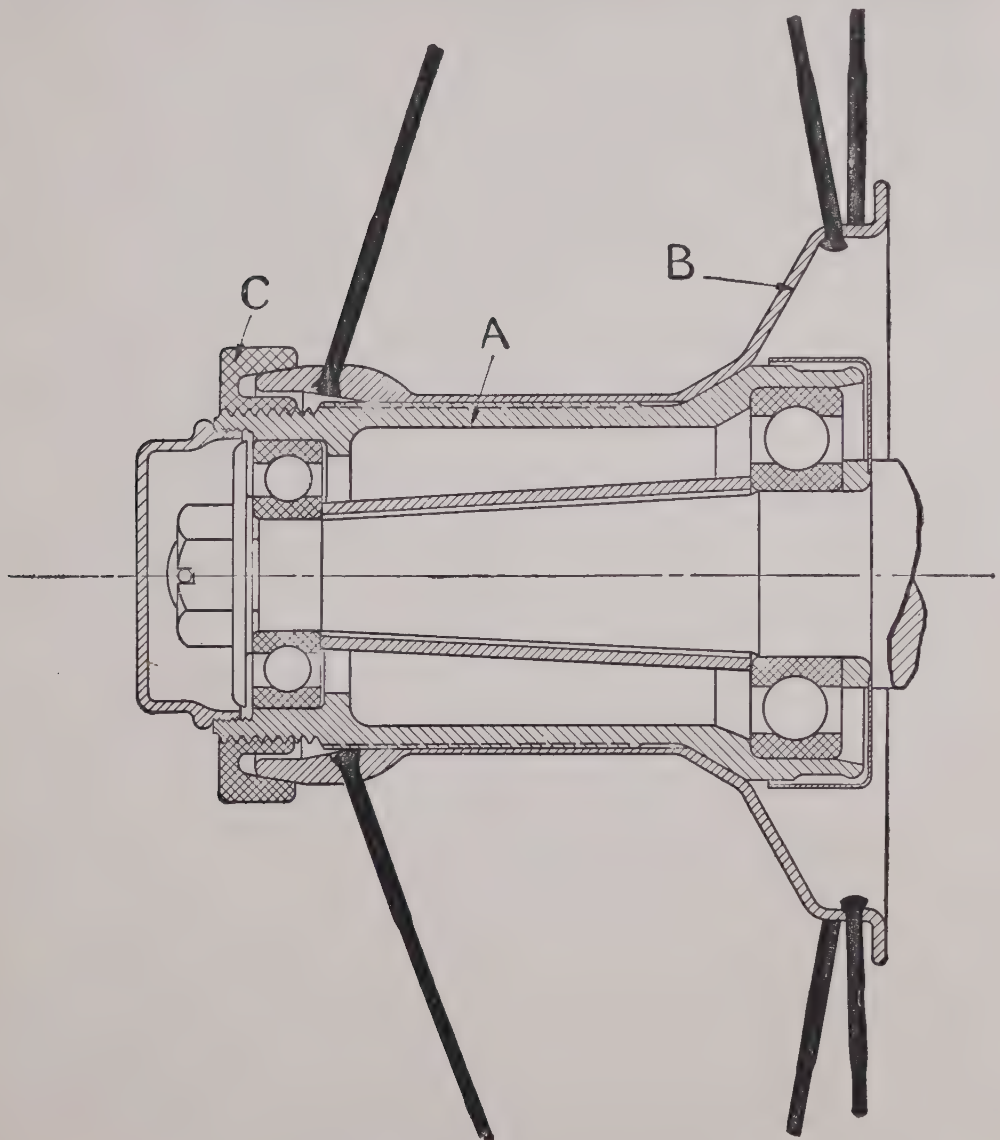


Fig. 43.—Detachable Wire Wheel Hub.

larger than the inner article, except in the purely mathematical cases where the two articles are the same size, which in practice is of course impossible.

Now when two such articles are revolved and kept in frictional con-

tact, it can be proved that the outer and larger article revolves appreciably slower than the inner one and therefore lags behind. This can easily be demonstrated—of course, on an exaggerated scale—by a walking stick and a serviette ring, or a lead pencil and a wedding or other symmetrically balanced ring.

It will be observed that the lock nut is exterior both to the inner hub and the shell of the detachable wheel, and consequently it will tend to lag behind them both, which is the same thing as revolving slowly in

Fig. 44.—Front View of Hub.

the direction opposite to that in which the wheel revolves. By selecting the threads in the proper direction this double tendency is utilised to make the wheel when once screwed up stay in its place. That is the principle involved in the new Rudge-Whitworth detachable wire wheel.

Among the minor merits of the new wheel is the fact that the serrations in the detachable wheel shell can be drifted straight through, an operation which is not done until the wheel is entirely complete and enamelled, so that the serrations are dead accurate and not thrown out

Fig. 1

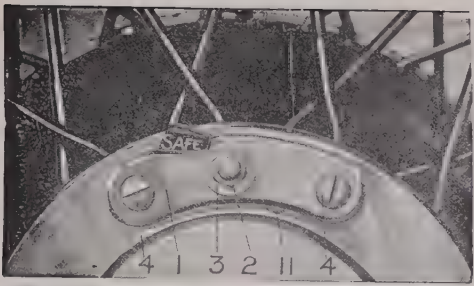


Fig. 2.

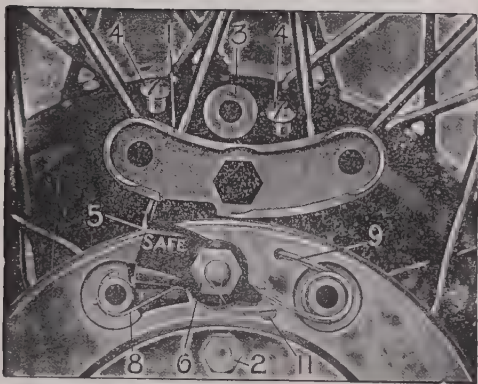


Fig. 3.

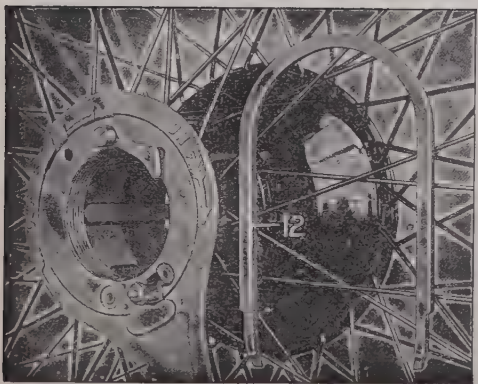


Fig. 4.

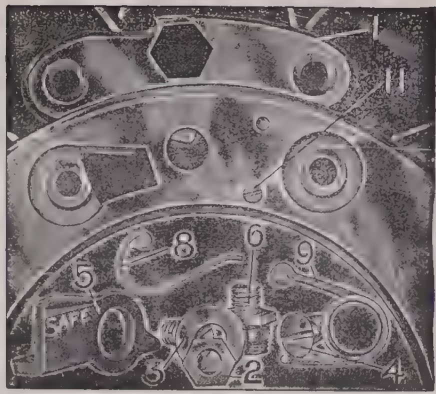


Fig. 5.

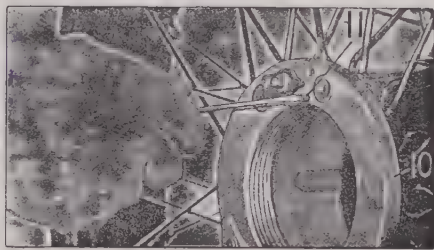


Fig. 6.

Fig. 7.

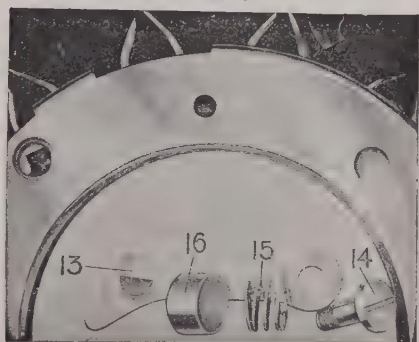


Fig. 45—Manipulation of Detachable Wheel.

by either the tensioning of the spokes in wheel building, or the extremes of temperature in the enamelling.

The seven Figs., 1, 2, 3, 4, 5, 6, 7, in Fig. 45 are given to show how to manipulate the detachable wheel.

To take off the pawl box 1, Fig. 1, first undo the hexagon nut 2 in the centre of the pawl box, and remove the small washer 3.

Then undo the two screws 4 at the ends, when the pawl box 1 can be lifted off.

It will be observed that the pawl 5, Fig. 2, is still held in place by the central stud 6, from which the hexagon nut 2 has been removed, and if the spanner 7 (see Fig. 3) is applied, the pawl 5, Fig. 4, will operate equally well, except that the springs 8 and 9 are liable to jump out; this is, when in use, prevented by the pawl box 1, Fig. 1. When the box is removed, one can check the action of the pawl and ratchet.

To remove the pawl 5 itself, screw out the centre stud 6, Figs. 4 and 2. This can be done with a movable spanner, or even with the hexagon hole in the pawl box 1 itself. (In screwing the stud 6 in again, it is necessary to leave it in such a position that the pawl box 1, when fitted over the hexagon of the centre stud 6, will come in the right position for the screws 4, Fig. 1.)

To remove the lock nut 10, Fig. 5, from the wheel altogether, first remove the pawl box 1, as instructed above; but it is not necessary to remove the pawl 5. A small grub screw 11 will be observed in Figs. 4, 2, and 6, at the tail of the pawl. This screw locks the withdrawal ring, which performs the double function of enabling one to pull the wheel off the inner hub, and of keeping the lock nut 10 in position when the wheel is carried as a spare. The removal of the lock nut 10 is very rarely necessary, and therefore the special tool 12 to do this is not included in the usual kit. After the grub screw 11 is screwed out, the withdrawal ring can be screwed off the lock nut 10, even without the special tool 12, by engaging the end of a file or chisel with one of the four notches in the withdrawal ring, and then turning the lock nut 10 right-handly (the screw thread between the lock nut 10, and the withdrawal ring being left hand).

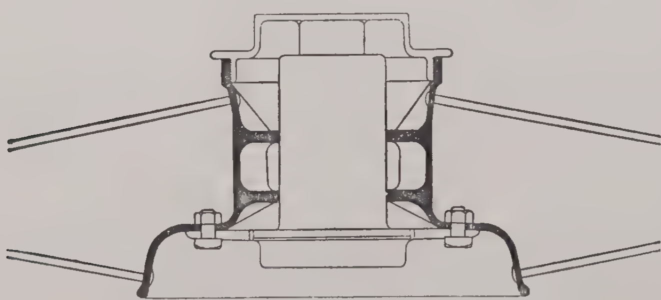


Fig. 45A.—Hub of Detachable Wheel.

To remove the lock nut 10 from the wheel, it is not necessary to interfere in any way with the hand-operated bolt 13, Fig. 7.

The hand operated bolt 13 is held in position with a single screw 14,

which is not liable to shake loose, because the spring 15, Fig. 7, acts like a spring washer.

The method of removal is obvious.

Another type of detachable wire wheel is shown in Fig. 45A, from which it will be seen that it bolts on to a flange on the inner end of the wheel hub.

The Care of a Detachable Wheel

1. Make certain that the wheel is thoroughly home after changing by observing that the proper amount of the inner hub projects through the lock nut.

2. Do not run the car with a loose wheel. The effects of doing so are that the driving dogs and the screw threads wear badly.

3. See that all wheels are kept constantly tight. Check by periodically rocking the wheel, and by applying the spanner to see if the lock nut can be turned farther round. These precautions are necessary, because grit is liable to get between the surface of the inner hub and wheel when it is being changed. The grit grinds away, and leaves the wheel loose.

4. In tightening a wheel, before removing the spanner see that the word "Safe" on the automatic pawl 5 is fully exposed (see 6 in Fig. 45); if it is not fully exposed, the spanner should not be pulled backwards, but should be forced further round until the pawl is fully exposed by engagement with the next notch.

5. When the automatic pawl 5 fully discloses the word "Safe," remove the spanner, and swing the hand operated bolt 13 into position. If it does not lie absolutely flush with the lock nut 10, it will not have engaged its ratchet, and it is a sign that the "Safe" disclosing automatic pawl is not in the correct position.

6. The insides of the wheels and the outsides of the permanent hubs should be kept thoroughly clean, and greased or oiled to prevent rusting or sticking. The wheels should occasionally be removed from the car, to see that their contacting surfaces are in good order and well oiled. The interior of the spare wheel can be kept free from dirt by carrying it on a dummy hub, or where the wheel is carried in the ordinary tyre clips by fitting one of the small dummy hubs provided for this purpose.

TYRES

Pneumatic tyres are used on all but the heavy vehicles. They played no small part in the evolution of power propelled road vehicles. Many substitutes have been attempted, but all without success. In a well paved street such as we find in London and other large cities solid tyres are fairly successful, but on ordinary roads only pneumatic give satisfaction.

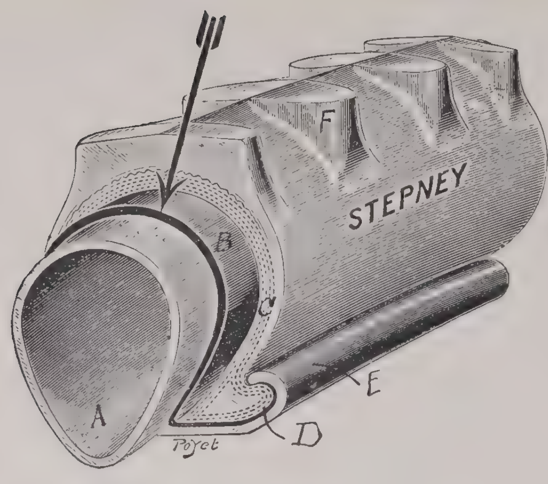


Fig. 46.—Pneumatic Tyre.

Any other spring than air compressed has a natural period of resiliency—that is, they take a given time to respond to a compression and a similar time to expand again—while the inequalities of the road do not occur at any regular periods; the consequence is that spring wheels do not cushion the car, for they either refuse to rise when over an obstacle, because their period of compression does not happen to coincide, or they are off the ground for an instant while their springs are expanding.

In the pneumatic tyre the air has no period of compression or expansion; it has no inertia to speak of. The flexible tube and cover yield at the contact with the ground, so that the tyre never loses contact and the weight of the car on the wheels is constantly "floated" on the air cushion in the tyre.

Pneumatic tyres are usually built up of several layers. First, the inner rubber tube, which must be wholly airtight and flexible; secondly, a strong cover; and thirdly, an outer tread of rubber, reinforced in various ways to strengthen the tread surface and to cause it to grip the road and prevent slip. Many are the different constructions of tyres, but essentially all are similar. In the one here illustrated in Fig. 46 we have the essential features shown. Here the inner tube of pure rubber is shown at A. In this particular tube a second cover B is fitted inside the outer cover C, made of special canvas and rubber, and the outer cover C of specially made strong canvas and rubber. On the outside a rubber facing F is vulcanised, and a beaded edge D on the cover fits into the flange of the rim of the wheel E. In this tyre the tread is formed

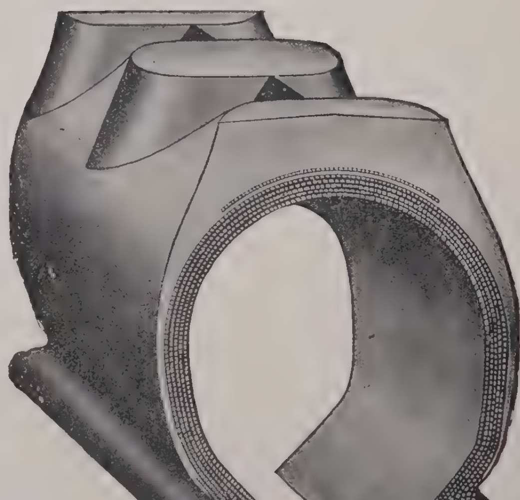


Fig. 47.—Rubber Padded Cover.

of rubber pads F, part of the rubber facing, also shown in Fig. 47, a section of the cover with beaded edge. These pads are designed to give a better hold on the road and to prevent side slip.

In Fig. 48 we have an example of another tread designed to give good road grip and no side slip. The tread is of moulded rubber vulcanised.

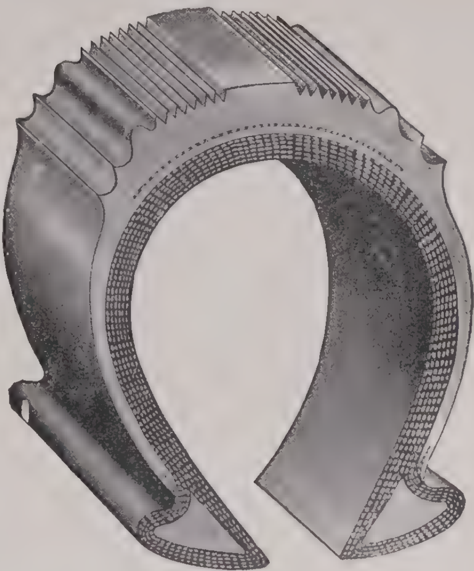


Fig. 48.—Corrugated Cover.

Another device to save tyre wear and tear is the studded tread. In the tyre shown, Fig. 49, the studs are of steel fastened in an outer rim of balata and canvas belting.

In another tread we find rows of alternate rubber and steel studs, the rubber to give grip and the steel studs to ensure long wear. This tyre is known as the Liversidge tyre and is shown in section Fig. 50 and complete in Fig. 50A.

It must not be forgotten that adding weight and stiffening the tyre cover reduces its cushioning effects. Theoretically, the tyre should be of light weight and very flexible. By encasing the air tube in a heavy stiff cover loaded outside with pads, or studs, or other treads of heavy weight, the tyre loses much of its pneumatic character and therefore we find that there is considerable vibration transmitted from the road to the car.

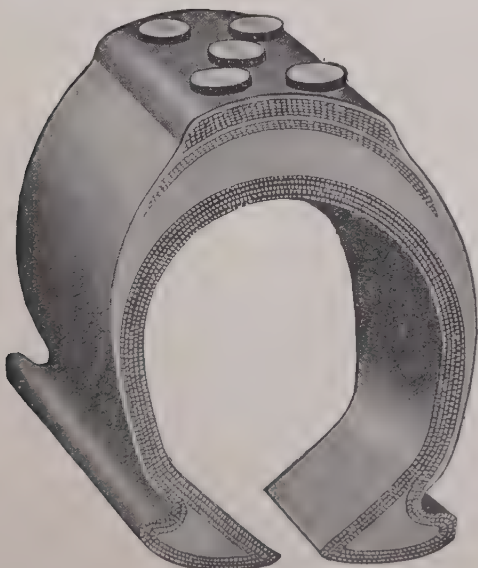


Fig. 49.—Steel Studded Tyre.

The fact is, the tyre, like most other engineering devices, is the result of a compromise. A good tyre which cushions well is not durable, for the cover must be thin and flexible. On the other hand, a durable tyre must have a strong, heavy, and somewhat stiff cover, greatly reducing its cushioning effects. The tyre maker combines the tyre in such a way as to get as much cushioning as is necessary with the greatest durability possible.

The ordinary pure rubber inner tube offers no resistance to pressure

inside. It is held in place and shape by the cover, so that if the cover becomes weak at some place, the inner tube is blown through. This is known as a "blow out." Inner tubes have been specially made reinforced by canvas. The inner cover shown in Fig. 46 is designed for the same purpose, namely, to prevent "blow out" through a weakened cover.

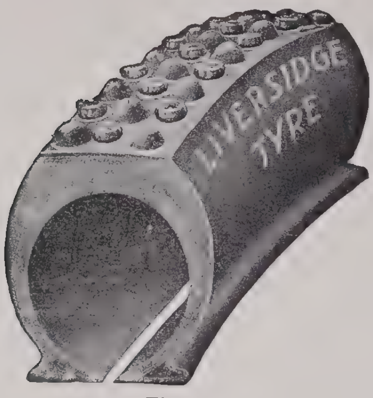


Fig. 50.
Rubber and Steel Studded Cover.

The solid rubber tyre is still used for heavy vehicles and performs fairly well. Its physical action is different from the air cushion. The air is compressible and, like a spring after compression, expands again when the pressure diminishes. Air has very small weight, hence a large volume of it may be used. A rubber tyre cushions by displacement of the rubber on the tread it flattens out, altering in shape, but not compressing into smaller volume. Rubber is not compressible. It cushions by resistance to alteration in shape or form, and recovers its shape or form when the pressure or tension is released, and the whole of the stress on the rubber is concentrated for the time being on the spot in contact with the road at any moment, whereas the air cushioned tyre has the pressure distributed by the air all over the tyre.

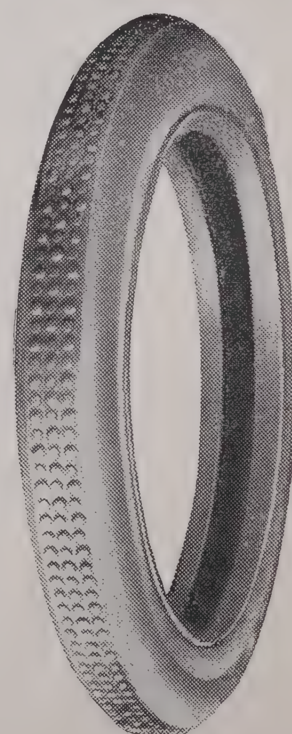


Fig 50A.
Liversidge Tyre Cover.

Many substitutes have been proposed for the air tyre. A solid, resilient filling has been used in the air tube. The stuff which has been used with some success is much the same as that used for printing press inking rollers—a compound of glue, glycerine, and bichromate of potash.

The stuff may be had ready made from suppliers to the printing trades and can be melted in the same way as glue, and run into the tyre tube; but it has drawbacks in use. It, like rubber, is not compressible. It cushions by displacement or deformation, and is apt to soften and lose resiliency when the tyre becomes heated by running on the road, and may even melt into liquid form.

Another substitute is spongy rubber filled into the air tube by pumping.

But no solid material is of any good as a substitute for a compressible gas like air; even a spongy material containing air is a poor sub-

stitute, for the air volume is small and a certain amount of air is necessary to form a proper cushion for the weight of the car.

The pressure of air in tyres is important. Too little pressure fails to keep the cover tight and it wears, due to flabby working. Suitable pressures are always given by tyre makers for each tyre and the weight to be put upon it. Thus:

Diameter of tyre	Weight on each wheel total	Correct air pressure.
65 mm.	325 to 450 lb.	50 lb.
	450 ,, 600 ,,	65 ,,
85 mm.	325 ,, 450 ,,	50 ,,
	450 ,, 550 ,,	60 ,,
	550 ,, 650 ,,	75 ,,
90 mm.	450 ,, 650 ,,	75 ,,
100 mm.	650 ,, 900 ,,	90 ,,

With the largest size of air tube, 150 mm. with over a ton on each wheel, the pressure is given as 120 lb.

The size of tyre is often given as required for the horse-power of the car, thus:

For	8 horse-power	85 mm.
,,	16 ,,	90 to 105 mm.
,,	22 ,,	105 to 120 mm.
,,	35 ,,	120 to 135 mm.
,,	75 ,,	135 mm.

The larger the tyre the better it stands to its work. The large tyre has less violent fluctuations in pressure, a large contact on the ground, and does not heat so much as the smaller tyre.

The inflation of tyres is a job of considerable hard labour when done by hand pumps. The best reciprocating pump taking the least power is one compressing in three stages, low pressure, intermediate pressure, and high pressure; such a pump with three cylinders is shown in Fig. 51. This pump has patent piston rod glands with no loose packing, and is capable of delivering one pound of air per stroke, and is tested up to 350 lb. per square with pressure. It has a ball joint at foot for folding up into car.

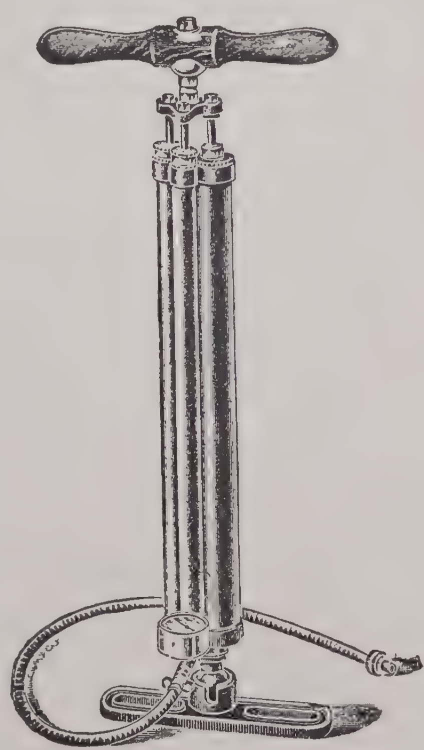


Fig 51.—Three Stage Air Pump.

A rotary motion, however, is much less fatiguing to keep up than

a reciprocating motion. Hence the small four-cylinder pump with a crank shown in Fig. 52, fixed to the footboard of a car. This is the best sytem for hand pumping.

Another system of inflation is used in which compressed air is carried in iron bottles, called sparklets. The air is compressed into the bottles at works specially devoted to the supply of compressed gases. The bottles carry each a supply for the largest tyres.

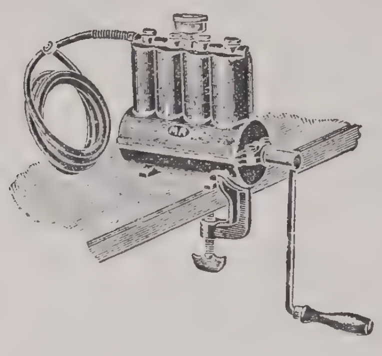


Fig. 52.—Four-cylinder Rotary Pump.

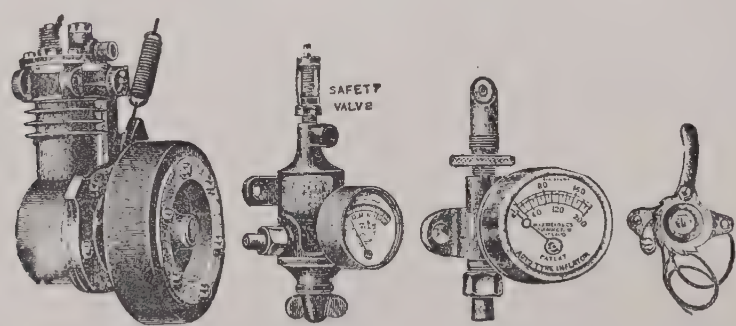
Another method employs a small air pump which can be driven from the engine (see Fig. 53).

The auto-inflator consists of a small air compressor, friction driven off the fly-wheel, or gear driven from the counter shaft.

The compressor cylinder, piston rings, piston, and connecting rod are similar to those in a small motor.

The crank shaft, balanced and case hardened, runs on two rows of large diameter steel balls, having adjustable ball races. The inlet and outlet valves are steel. Every machine is tested to 250 lb. square inch.

There are two sets of lugs cast on the top of cylinder, to which a



Pump. Safety Valve, with Gauge. Gauge, Dashboard fixing. Lever and Cable.

Fig. 53.—Flywheel Driven Pump and Fittings.

small interchangeable swing bracket is attached; this is arranged for convenience for fixing the compressor, either on the right or left side of flywheel.

On this bracket is mounted a cam, bearing against the crank case; this cam is attached by a flexible cable to a small operating ratchet lever (this lever is conveniently attached to the step or dashboard). By means of this lever, the compressor swinging on the small bracket

is caused to come into contact with the flywheel. Upon release it is automatically brought out of contact by a spring attached to the bottom of crank case and bracket. Thus the compressor can be instantly started or stopped. The compressed air from the compressor first passes through a copper tube connected to a small air chamber. This air chamber is constructed of gun-metal, and is fitted with a pressure gauge, adjustable safety valve, and a filtering device for cleansing the compressed air of any impurities before passing through the long length of detachable flexible tube into the tyres.

Another system employs the engine compression as follows:

An automatic pump for forcing pure air into the tyres of motor car wheels is shown in section in Fig. 54, and complete with a coil of rubber hose pipe for connecting it up to the tyre valve.

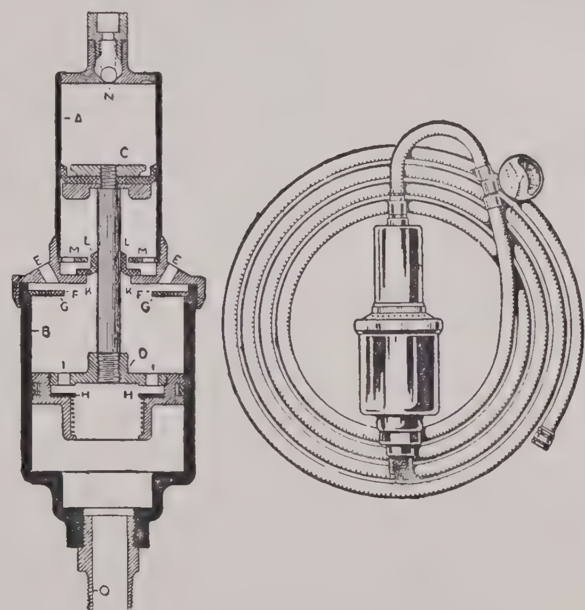


Fig. 54.—Compression Tyre Pump.

The pump is screwed into one cylinder of the engine in place of the sparking plug and is worked by the compression of the engine.

The pump has two cylinders, A and B, of varying diameter (Fig. 54) with a flying double-diameter piston C D, working within them. All the air is taken in through the series of holes E E, around the central division piece of the pump. There is also a series of holes I I, in main piston D, of the pump itself, but the collective area of these is less than the collective area of the others, so that, on the induction stroke of the engine, whilst air passes straight through the pump into the engine (for purposes of compression only) there is always a sufficiently greater pressure above the piston to force it down and, at the bottom of its stroke, the larger or power cylinder of the pump is full of pure air. Upon the return, or compression stroke of the pump, the valve H H, in the base of the piston D, closes, with the result that, whilst it becomes impossible for any of the mixture in the engine cylinder to pass beyond this point, the air within the pump cylinder is trapped by the simultaneous closing of valve F G, below the points through which it entered. Simultaneously also with this, the "hat" washer L L is carried upwards by its frictional contact with the rising connecting rod, until it abuts against and is

held by the perforated plate above it. This opens the cylinder B to ports M M, and as the pistons rise, the pure air contained in B is compressed through the ports M M into the smaller or pump cylinder A, and passing above the smaller piston on the next down-stroke, is compressed through valve N into the tyres on the next upward movement. It will be seen that several advantages accrue under this system of construction. Firstly, as no contaminated air can possibly pass the valves in base of the piston, it is impossible for any such air to enter the tyres, which can only be filled by the pure air trapped in cylinder B. Secondly, the pump must be efficient, as only the cubical area of the larger and not of both cylinders of pump is added to compression space of engine, thus giving a higher possible maximum force exerted on the base of the power piston to work the pump. The construction is simplified and the length, weight, and bulk of the pump enormously reduced. It will be seen, too, that it is a true two-stage air compressor, or compound pump, going straight to its work and compressing *nothing but pure air into the tyres.*

The Pushon pump connection to the inlet valve of the tyre is shown in Fig. 55 complete, and in Fig. 55A in section. Fits all sizes and makes of valves, thus dispensing with different adapters. No twisting swivel joint is required, as the connection simply pushes on and the rubber washer automatically makes a perfectly airtight joint. If the pump has a non-return valve and gauge this latter will show the exact pressure in the tyre, as there is no leak at the valve. When the rubber washer becomes worn a spare one can be easily fitted. In cold weather the B.B. Pushon connection can be manipulated with heavily gloved hands.

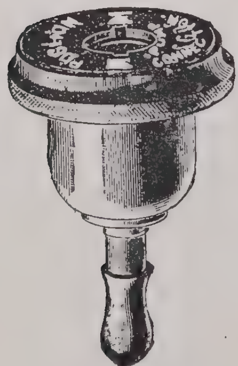


Fig. 55.

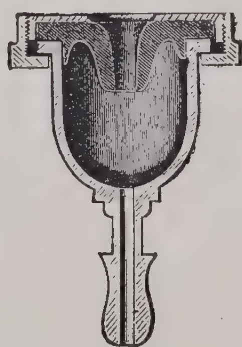


Fig. 55A.

Pump Connector.

STANDARD RIMS

The committee appointed by the Society of Motor Manufacturers and Traders to standardise wheel rims have arrived at some important conclusions, and have decided as follows:

The standard rims with their gauges are lodged at the offices of the Society and are available for inspection and use by any member. Five standard dimensions have been set for rims to accommodate different sizes of tyres, namely, 65 mm. to 75 mm.; 90 mm.; 105 mm.; 120 mm.; and 135 mm. For each of these sizes the circumferential length

is given for each of the diameters in general use, thus for the 120 mm. size the circumference is determined for 820 mm., 850 mm., 880 mm., and 920 mm. tyres. All the internal dimensions of the different rims and the radii of the three curves that come into each rim were definitely determined, and if these dimensions are adopted by all manufacturers of rims and tyres a very valuable service will have been rendered to the community.

In order to arrive at the various dimensions that would commend themselves to the different makers, and to avoid the possibility of the work of the Committee being brought to naught because of the need for the wasting of tyre moulds, great care was taken to secure a correct basis for each dimension. Rims of all sizes and makes were purchased, sections were cut out of them, and the mean and extreme dimensions of each size were obtained. These measurements were summarised and compared with the standards already recognised by the different makers of tyres and rims. It was proposed to make the width between the lips of the flanges some proportion of the nominal size, but, whilst in some cases the result approximated the average dimensions, in others the difference was great enough to cause considerable difficulty with security bolts and even air tubes. It was therefore decided to accept practically the average measurements for the width.

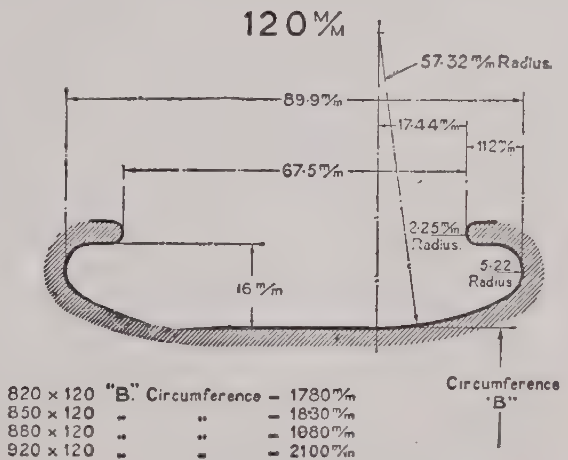


Fig. 56.—Standard Rims.

It was found that the average depth increased in steps of approximately 2 mm. for the smaller sections: namely, 65 mm. rim, 10 mm. depth; 90 mm. rim, 12 mm. depth, and so on. In the case of the 135 mm. rim the average depth was found to be 17 mm., and this depth was apparently considered sufficient for all larger sizes. The other dimensions of the rims were made proportionate to these depths. Hence, the width and the depth of a rim being given, it is easy to design a rim that shall in every respect be proportionate to the existing standard rims.

Fig. 56 shows one of the sections adopted with the dimensions given in millimetres.

SPRINGS

The springing of the car is an important feature. Upon it depends the comfort of the passengers on rough roads. The art of designing

springs for road vehicles is no new one. Horse drawn vehicles require well designed springs quite as much as motor cars, and the old coach-builders devoted much care in springing their coaches, and besides had learned much by long experience. But their accumulated knowledge does not seem to have been taken advantage of by motor car designers. Few motor cars have the smooth, easy motion of a first-class coach of earlier days. Possibly this is due to a large extent to the body of the coach being somewhat free of the chassis in old coaches.

The pneumatic tyres form a spring between the road and wheel, and these cushion the wheel against the smaller irregularities of the surface. On a railroad pneumatic tyres are unnecessary, the surface being of smooth steel. But good springing between the axles and the body or frame is still necessary even on a railroad to cushion against the rise and fall of the rails when the weight passes over them.

The pneumatic tyres cushion against the smaller irregularities. The springs are, or should be, designed to cushion against the larger irregularities of the road. If we observe a car on the road this may be seen. The tyre flattens out more or less over the small obstacles, while the axles rise and fall over the larger obstacles.

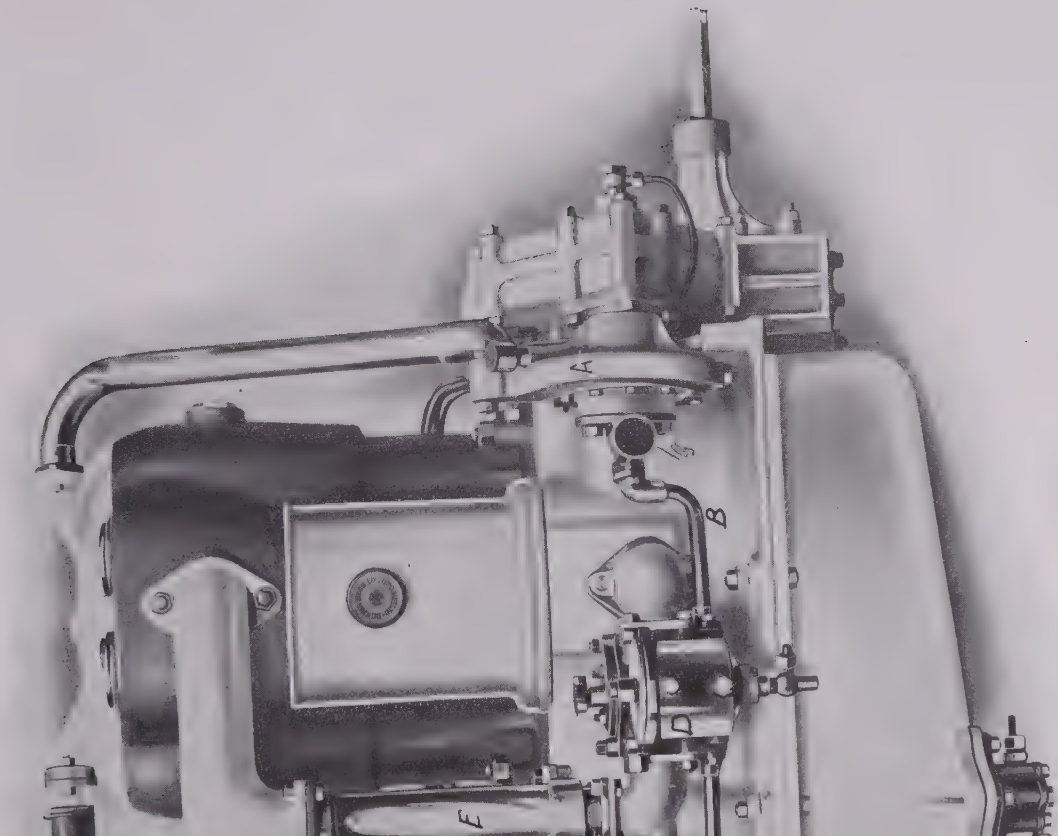
Generally speaking, long springs with many leaves are best; they give a large deflection and have a slow period of vibration, and the large number of leaves in the spring gives an amount of friction which deadens the shocks by retarding the motion of the spring.

The important subject of springs is well dealt with by Mr. Leavett J. Lane in a paper for the annual meeting of the S.A.E., New York, January 1913.

We may here refer only to the subject of the material for springs as therein given.

"The first consideration in spring design is the steel composition. The ordinary spring steel lacks strength and elasticity and has not the resistance to fatigue characteristic of some of the comparatively recent alloy steels. Manganese, nickel, silicon, chromium, vanadium, and high carbon steels are used to a greater or less extent, but the best results seem to be given by springs made of alloy steel composition, such as chromium vanadium, nickel chromium, or silico manganese. Of these the vanadium alloys are to be preferred. But no matter how good the steel primarily, the secret of the steel spring lies in the end in the heat treatment. A recent comparative table of the physical properties of vanadium and other crucible steels gives the following peculiar properties of vanadium steel. The different steels were oil tempered at 1,500° F. and drawn at 600° F.

	Tensile strength. Pounds per square inch.	Elastic limit. Pounds per square inch.
Carbon	126,300	101,100
Nickel Chromium	150,300	134,500
Nickel Chromium Vanadium	163,700	152,300
Chromium Vanadium	233,090	210,500



Dennis Engine, showing Circulating System, Carburettor Heating, and Circulating Pump.

"Vanadium steel is practically non-fatiguable and consequently does not readily fail under the repeated shocks to which a spring is subjected. According to one authority, William E. Snow, from one of whose articles the above table was taken, a crucible carbon steel spring was broken by 125,000 alternations of the testing machine, while the chromium vanadium steel spring withstood 5,000,000 alternations and remained unbroken."

Vanadium steel is rather expensive, but its great superiority as a steel material for springs makes it worth while using it in high-class cars.

The various types of springs in use are shown in Fig. 57, A, B, C, D, E, F.

A shows the first leaf of a spring with scroll end eyes formed by

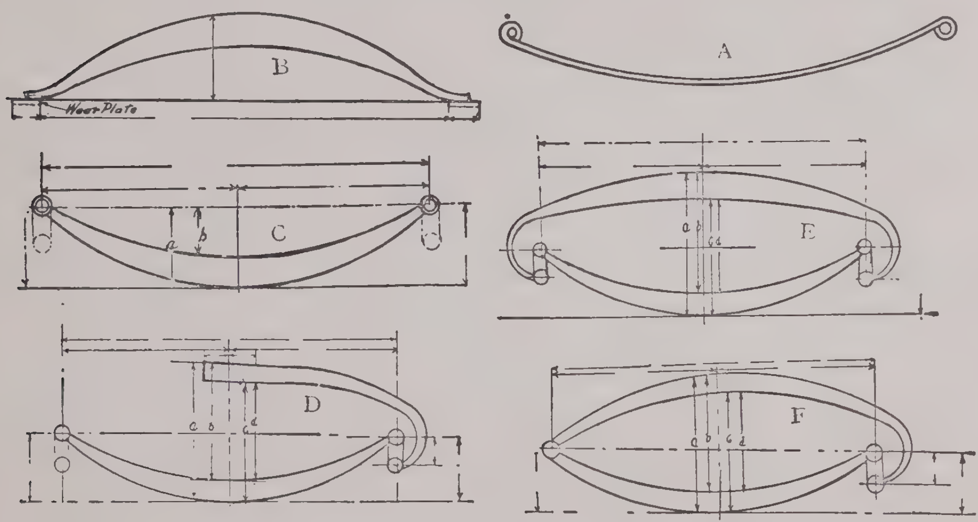


Fig. 57.—Coach Springs.

bending over the end of the plate or leaf. It is as good as any end eye when properly made.

B is a single elliptical spring with ends sliding on a wear plate.

C is an elliptical spring shackled at both ends.

D is the common three-quarter spring shackled at both ends.

E a double elliptical spring shackled at both ends, and F the same shackled at one end and on a pin at the other.

Sometimes transverse springs are employed at the rear axle shackled to the longitudinal springs to give a three-point suspension.

The purchaser of a car can decide as to whether the springing is good or not by testing the car on a rough road; one with obstacles of some size, billowy and humpy. A good sprung car should drive over shallow cross trenches or cross laid sleepers 4 to 5 inches thick on the road. A test on a newly macadamed road, if fairly evenly laid, is of no value in judging springs.

Springs as a rule give little trouble when properly designed for the road and load and speed. The only attention required is to keep them clean and oil the shackles, joints, and between the leaves. A car sometimes develops a squeak, which is usually due to friction between the spring leaves. Oil makes them quiet, and also more resilient.

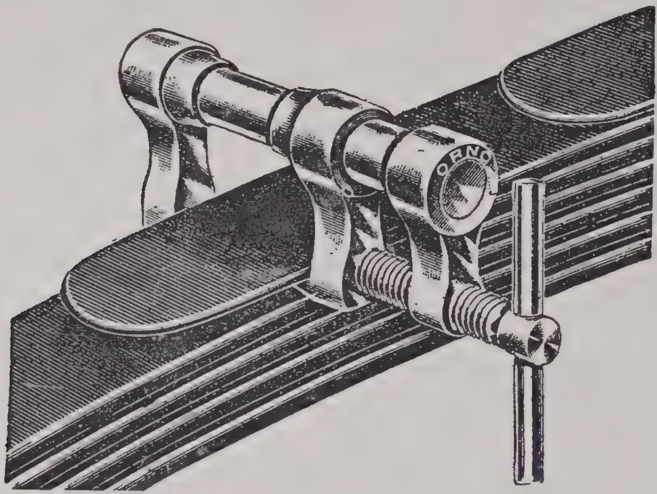


Fig. 58.—Spring Priser

For the purpose of prising open the leaves of springs in order to lubricate them the tool shown in Fig. 58 will be found useful. It consists of a strong cross bar fitted with wedge shoes and a powerful screw whereby the leaves are wedged open.

Some use a mixture of graphite and thick oil; others use graphite alone as lubricant for spring leaves.

SHOCK ABSORBERS

Many car owners have had to consider the question of fitting shock absorbers to their cars. Experts are divided on the question. Some advocate their use, others deem them unnecessary, alleging that if a shock absorber is necessary, then there must be something wrong in the design of the springing of the car. A car with correct size and weight of springs should require no additional springs.

When a car, however, passes along a road with an undulating surface the springs are compressed and extended alternately. The inertia of the car and load prevents its immediate change of motion and some force is necessary to assist it in its upward and downward movement or acceleration. The movements of the spring react on the body, giving it an upward thrust on ascent; on the descent the extension of the spring allows gravity to give the body a downward thrust, and thus it is kept in vibration.

And if the natural period of the car and springs is approximately that of the undulations on the road, the vibrations become very uncomfortable.

The true shock absorber is designed to damp out these vibrations.

Frictional shock absorbers have been used in the form of a plate

friction clutch, which is given enough pressure to retard the motion of the car up and down on the springs.

There are many forms in the market, chiefly designed in order to allow of their being readily adapted to existing cars without much labour or any fittings other than those supplied by the makers of the absorber.

The shocks are generally of small amplitude, but occur in rapid succession, and are of course very unpleasant. They are more marked on the rear springs, because the front springs, which carry the weight of the engine, can be designed for a smaller variation in load than the back springs, which have to work both with a full load in the back of the car and with the back empty.

It is therefore on the back axle that there is the greatest need for

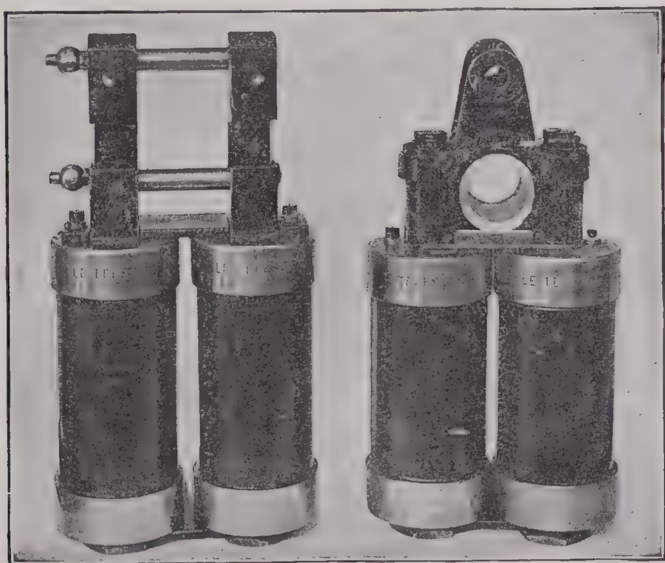


Fig. 59, 60.—Telesco Shock Absorber.

some device to absorb these small shocks. The use of a light spring at once suggests itself, but this would necessitate some form of brake to prevent surging. In the Telesco shock absorber this necessary brake is applied in an ingenious and effective way (see Fig. 59, 60). It acts only when the spring is expanding, and so takes the rebound without reducing the ease with which the shock itself is absorbed. Further, the Telesco spring expands so much more slowly than the ordinary road spring, that when the road spring has reached the extremity of its movement and is returning, the Telesco spring will still be expanding. Thus they will be in opposition and the movement of the body of the car will be reduced.

Shock absorbers have been the object of interesting and numerous investigations by the large manufacturers, and it has been acknow-

ledged that however well the springs of a car are designed, they have a definite limit, and that a device must be fitted which will help the springs to work under the varying conditions to which they are subjected.

Some form of brake is required in order to prevent bouncing and surging, and the brakes which have been devised for this purpose may be placed in three classes—friction brakes, producing a constant resistance, progressive brakes, and hydraulic brakes.

The objection to friction brakes is that they are inadequate and dependent upon the state of the surfaces in contact, and when their efficiency increases, the strain on the tyres when the wheel mounts an obstacle is increased, as well as the skidding and slipping after passing an obstacle owing to the wheel not keeping the road.

Progressive brakes, which necessitate a previous increase in the flexibility of the springs and provide for a determined load only, are open to the same objections.

In the Telesco all objections to suspension brakes are overcome. Let us suppose that the axle rises suddenly upon meeting a bump in the road. The two springs, the laminated and the Telesco, are simultaneously compressed proportionately to their flexibilities, but when the inverse motion of expanding is produced, the laminated spring alone is freely expanded, and the vertical reaction of the suspension upon the car will be great in proportion as the Telesco has absorbed a greater portion of the compression and the restraint upon its expansion is more accentuated. Hence, the total expansion of the suspension is diminished, slackened, and moderated, and yet there has been no antagonistic action against the motion of the chassis, as was the case in the brakes previously considered.

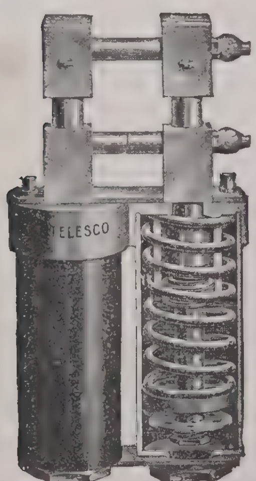


Fig. 61.

In the case of small oscillations, which are short and rapid, the absorbing device upon the rising of the Telesco is arranged in such a manner as to be inoperative altogether, and to leave to the apparatus all its elasticity and rapidity of motion in the two directions necessary in order that the vertical accelerations imparted to the car should be as feeble as possible.

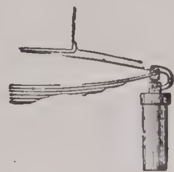
The Telesco, Fig. 61, is a vertical cylinder three-quarters full with a liquid, and enclosing a piston pressed downwards by a spring. When a shock is encountered, raising the piston and compressing the spring, the liquid passes freely through the piston, but when the spring expands, forcing the piston downwards, a valve closes, allowing the liquid to pass through two or three small holes only. The piston is therefore free when rising in the cylinder and resisted in descending

Shock Absorbers

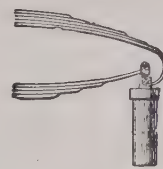
In Fig. 62 the various types and their fitting to a car spring are shown. In most cases they fit in place of the spring shackle, and in Fig. 63 the absorber is seen as usually fitted on the back springs.

Another hydraulic system is the A.V. system. This absorber is shown in Figs. 64 and 65, type A for front springs and type B for rear springs.

Type A is smaller designed to cushion the front part of the car and the engine. This type can be placed on practically every car, owing to its diminutive dimensions. It does not interfere as a rule with the rear end shackle of the front spring, or the connections of the steering. It is fitted up by merely bolting it on the rear end shackle of the front spring. It is considered necessary to use a front shock absorber for the simple reason that all shocks before reaching the back wheels have to be supported by the front wheels, therefore by the engine, and, owing to the leverage, in the absence of front shock absorbers, these shocks, which are received almost at the same time by the back wheels, are considerably increased.



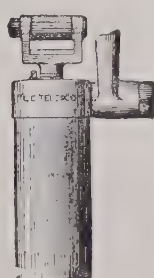
Twin Telesco fitted to Car with Dumb Hanger.



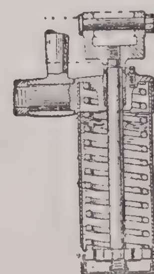
Twin Telesco fitted to Car with ¾ Elliptical Springs.

Telesco Fitted to Car with Cross Spring.

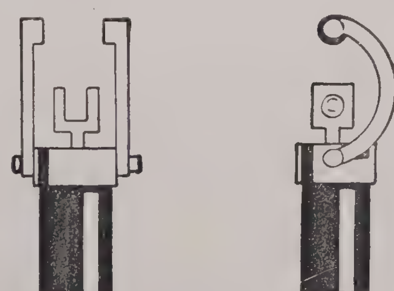
Special Twin Telesco Fitted to Car with Crossbar and Semi-Elliptical Springs.



Single Telesco with Fork. (Elevation.)



Single Telesco with Fork. (Section.)



This Type is also Suitable for the Back of the Front Springs.

Fig. 62.

A sectional view of this absorber is shown in Fig. 66 in plan and elevation, and the following is a reference table to the parts :

A, Large cylinder.
BB, Small cylinders.
C, Guide of piston E.
D, Large piston.
EE, Small compensating pistons.
F, Large suspension spring.
HH, Restricted passages for oil.
I, Screw regulating the tension of spring F.
J, Small valve.
K, Leather cover.
L, Collar fastening cover K.
M, Grub screw taken out for filling up with oil.
N, Nut securing screw I.
O, Oil level.

It will be seen to consist of one large cylinder with a telescopic ram, communicating at the bottom with two smaller cylinders and pistons.

Fig. 63.

The pistons have a small valve J. It is filled with oil to the level N, so that there is a cushion of air in the hollow ram or piston, D. The passage H is small and restricts the flow of the oil between the large and small cylinders, and prevents the quick rebound of the spring, and for the same purpose the compensating pistons are bored with several restricted passages to allow of the oil circulation, prevent too quick a recovery of the coil springs, and regulate their work according to the shock.

The small valve J is fitted in order to prevent compression of the oil on the top part of pistons EE.

When filled up to level shown with oil (castor oil for preference) the absorber is lubricated in every moving part. The disposition of the three-coil springs between the chassis and the road spring constitutes a remarkably elastic shackle, absorbing all the road shocks, and only permitting the road spring to work when exceptionally big shocks are received.

The rear shock absorber is shown in section Fig. 67, and the following is the table of references:

Shock Absorbers

A, Bottom cylinder or sleeve.
B, Compensating cylinder.
C, Top portion for road spring bolt.
D, Top cylinder acting as piston.
E, Compensating piston.
F, Large suspension spring.
G, Small shock damping spring.
H, Screw regulating the tension of the springs.
I, Top cylinder acting as cover.
J, Leather of compensator.
K, Restricted oil passages of compensator.
L, Grub screw taken out for filling up with oil.
M, Nut securing screw H.
N, Oil level.

In the same way as the front shock absorber, the rear shock absorber when filled up to the level shown with castor oil, in preference to any

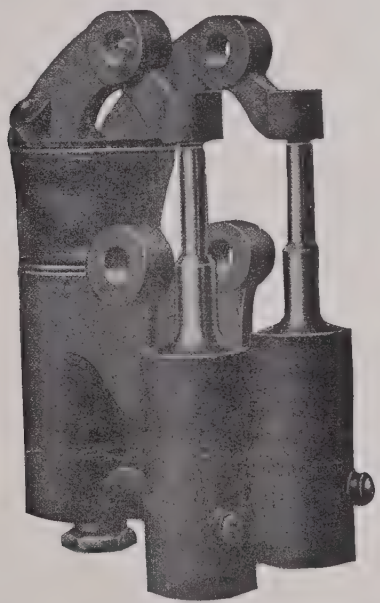


Fig. 64.—Type A. Shock Absorber A.V.

Fig. 65.—Type B.

other oil, has every moving part constantly lubricated. The spring F is provided to act as a suspension spring while the overload and the shocks are absorbed by the damping spring G and the road spring.

The above mentioned arrangement has been proved to give a perfect suspension under variable loads on bad roads.

The compensating cylinder is bored at various points with holes, regulated to admit sufficient oil to prevent the quick rebounce of the springs, and to regulate the work of the shock damping spring when several shocks follow each other rapidly.

The smaller compensating cylinder is inside of the larger cylinder.

The instructions for fitting this shock absorber are as follows:

Lift up the chassis in the centre, to prevent warping, using a jack

and a transverse wood stanchion ; take away the spring shackles. A steel rod should be inserted in each spring eye, hanger, or bolt guide in order to make sure that these are parallel, both viewed in plan (viz. looking over the spring) and viewed in face (looking at the rear of the car). Should this parallel not exist, the hanger or the spring should be modified accordingly. The shock absorber should then be fitted,

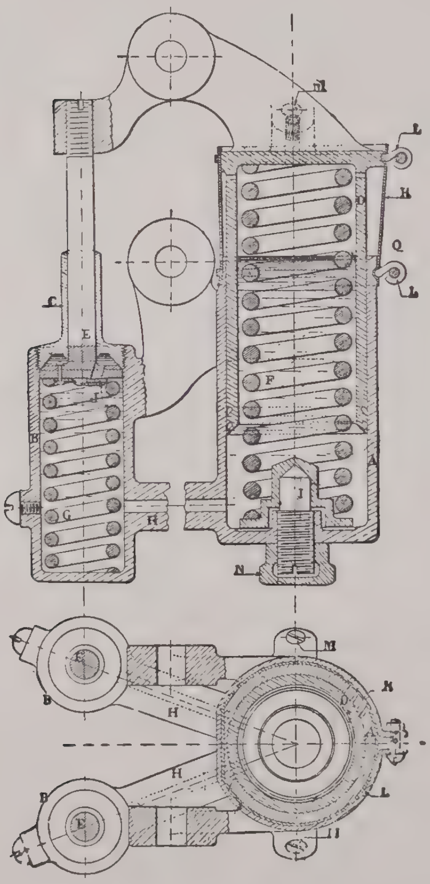


Fig. 66.—Type A. Section A.V. Shock Absorber.

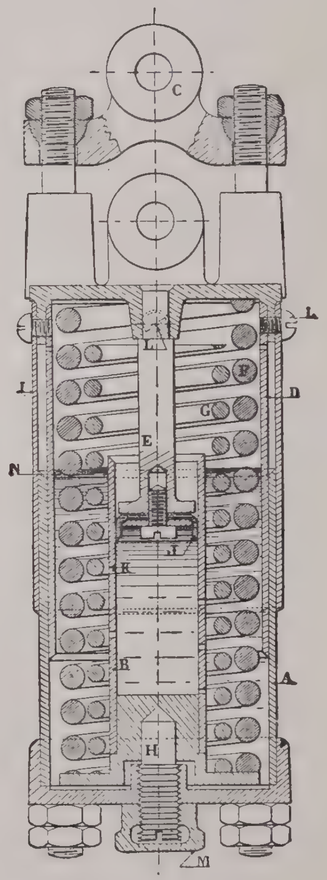


Fig. 67.—Type B.

starting with the bottom bolt ; the top bolt should then be inserted and no effort should be experienced in pushing it lightly if the parallel above mentioned is perfect ; tighten the nuts, by hand, and fit the split pins (never use a spanner to tighten nuts, as this would tend to warp the shock absorber head and prevent it from working). Take the jack away, and make sure that the shock absorber not working is slightly inclined towards the rear of the car, so that when the road spring is working the shock absorber has a tendency to the perpendicular.

Should this angle exceed about 10 degrees it is advisable to modify the hangers or the spring eyes.

If these instructions are acted upon when jumping lightly on the footboards the shock absorber will be seen to work.

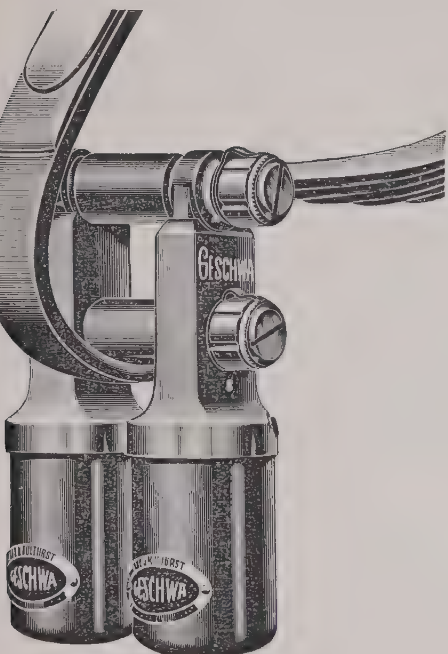


Fig. 68.—Parsons Shock Absorber.

The Parsons shock absorber is shown in Figs. 68 and 69, an external view and section. The important feature is the design of cylinder and the springs. The springs are of volute type, practically unbreakable and retaining their resiliency constantly. At the same time they take up shocks with smoothness and produce easy running. This result is assisted by the fact that the cylinders containing the springs form a kind of inverted air pump, the leather of which will be seen immediately under the platform of the rod on which the spring is carried. On the down stroke of the spring the pump offers no resistance at all to vertical motion, but on the up stroke the air above the piston is trapped in the top of the case, whence it can only escape comparatively slowly. This effectually damps any tendency in the spring to develop a "bounce."

Other advantages are the system of automatic lubrication, both of the springs and shackle bolts; neatness of design, economy in weight, and the small number of working parts. It is easily fitted, and the shackle bolts are so arranged by means of interchangeable sleeves as to fit varying sizes of shackles.

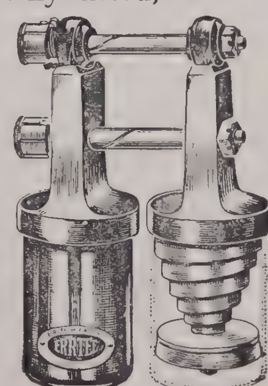


Fig. 69.—Parsons Shock Absorber.

A shock absorber of rather different type is shown in Fig. 70. It is called the Gabriel snubber. The axle is connected to the frame by a strong balata belt, and it allows the axle to rise easily but retards its fall. Referring to Fig. 70, the circular steel case F is fixed to the frame of the car, and the end of the balata belting to the axle of the road wheels. When an obstruction causes the car springs to compress, the slack of the balata belting is taken up by the extension of the coil spring C. As the car springs commence to re-

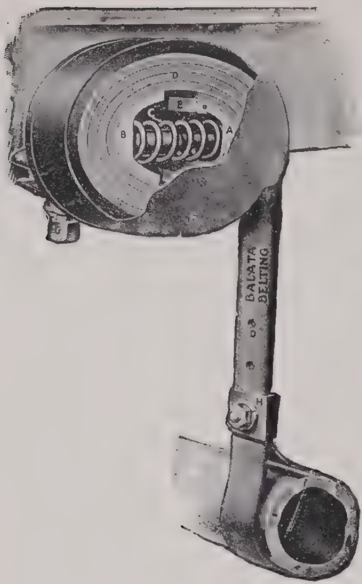


Fig. 70.—Snubber.

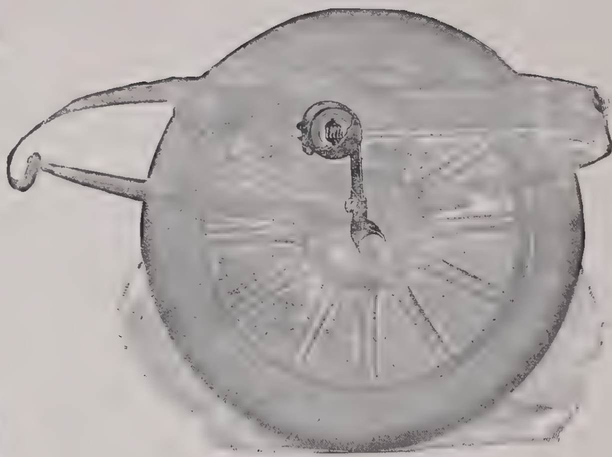


Fig. 71.—Snubber.

bound, a metal band in the snubber causes friction with the balata belt (which increases as the coil spring compresses). This action effectually checks the rebound of the car springs.

Fig. 71 shows the snubber as fixed to the rear spring or axle, and Fig. 72 shows it on the front axle.

The following instructions must be observed:

Attach the snubber firmly to the frame of the car by means of the two side screws or locking nuts, then fasten the belting to axle so that it is taut and lined up true sideways; after ascertaining proper length, cut the belting off, fasten the clamp close to the axle or front spring and so the turned edge of plate will cover the end of the belting; then release the tension by removing the nail from belting.

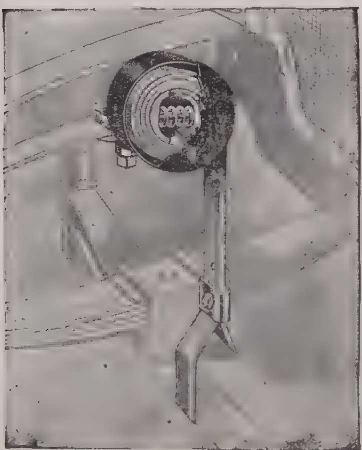


Fig. 72.—Snubber.

The snubber may be placed on a frame either before or behind the axle as required. Place same so that it will not strike the axle when springs cómpress. Turn the cover so that the belting does not chafe anywhere. See that all screws are tight.

The balata belting should not slide on the axle. It can be kept in place by stretching a piece of wire between the two lengths of belting or by fixing a screw into the axle.

Before leaving the factory the snubber

is pulled to its proper tension and held there by a nail, *which must not be removed* until the snubber is fitted on the car. The nail is then taken out and the snubber ready for use. *Before removing the nail, take great care that the belting is quite taut.*

Should the belting stretch after the first few hundred miles, it is necessary to make it quite taut by taking up the slack and readjusting the clip.

Many attempts have been made to introduce the rubber and air

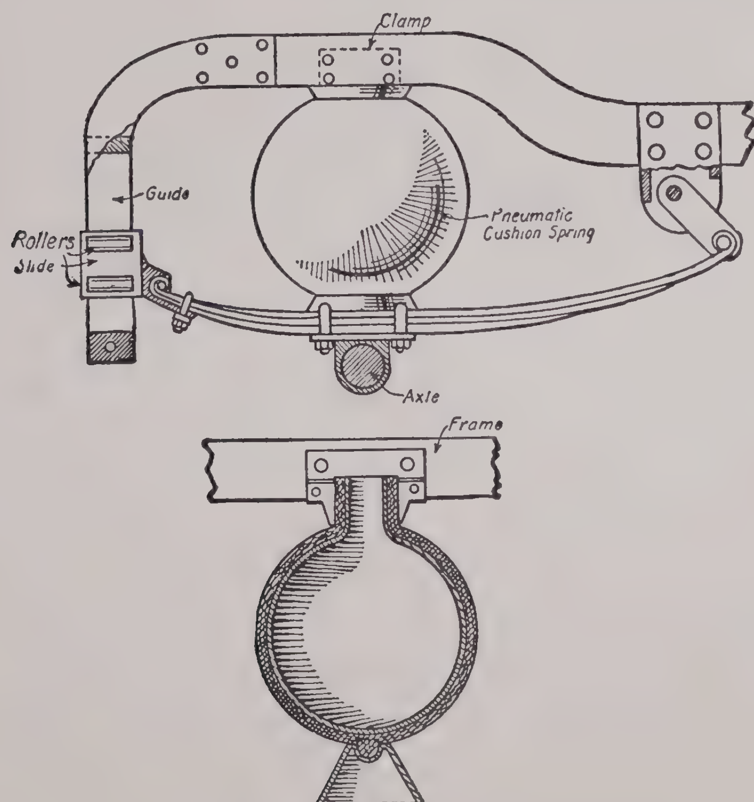


Fig 73.—Pneumatic Cushion.

cushion between the road and the chassis, elsewhere than on the wheel rim, but without success. An American device described by W. Henry Sturmey in *The Motor* of July 12, 1913, seems a promising one. American roads are very primitive; our worst country lanes are superior to American best main roads; hence the springing of American cars is of more importance.

In this present device, Fig. 73, the chassis is carried by rubber balls between the axle and chassis.

The balls or cushions are mounted on light elliptical springs. The

springs, however, take more of the load. They are used to centre and steady the bulbs.

The air bulbs are held between the apices of conical plungers. When the wheel is forced up over an obstacle the balls are flattened and deformed by the cones, as will be readily understood from Fig. 73, a side view and a section of the bulb. The light three-plate springs are shackled at one end and arranged with rollers at the other to slide in vertical guides formed for them in extensions of the frame sides, so that they move consonantly with the deformation of the air cushions.

Between each pair of cushions a cylindrical air reservoir is fitted and the interiors of the air bulbs and of the reservoir are connected by tubes. A non-return valve on the reservoir serves for the inflation of both cylinder and bulbs, and the action is as follows:

As the car wheels are raised by passing over road obstructions, the air bulbs are deformed and a certain amount of air is displaced from the cushion and forced into the reservoir, thus slightly increasing the pressure there. At the same time, the deformation of the shape of the cushions by the apices of the conical supports increases the supporting area of the cushions in accordance with the violence of the shock administered, each inch or fractional part thereof sustaining the blow rendered, the shock therefrom being absorbed by the merging of the air displaced from the cushion with the air in the reservoir very much in the same way as, in the case of a pneumatic tyre, the deflection of the tread increases the supporting area and the shock is absorbed in the body of the tyre. The reservoir and bulbs are charged with an ordinary hand pump. It will be observed that the shocks caused by road obstructions are met by a very large proportionate increase in the contact area of the cushions with the conical surfaces of the plungers, the plungers, in this case, taking the place of the ground, whilst the absorbing of the air displaced by the auxiliary reservoir allows a long travel of the plungers into the cushions by the inward folding of the cushion walls and a soft, easy reaction or reformation of the cushions, thus obviating any violent rebound.

If it were possible for a leaf spring to keep the tyre firmly on the road during action there would be no skidding or grinding of the tread, and, hence, no generation of heat from that source, but merely a conformation of the tread to the road irregularities, traction would be increased, and the service of the tyre would be measured by the natural life of the material of which it is composed. But that is not possible with any form of tyre and with any form of spring, especially a steel one. It is claimed for this device that it gets nearer the ideal in this respect than is possible with springs of the ordinary character, that its resiliency as compared with the ordinary leaf spring is very similar to the difference between the pneumatic tyre and the solid or cushion variety, and that its vibration-neutralising ability is manifested in a saving not only of the chassis, but of the tyre employed by damping

the vibrations and, thereby, holding the tyre more firmly to the road surface.

Seeing that nothing not in direct contact with the ground can replace the pneumatic tyre as an absorber of the small vibrations, it is not put forward as a substitute for the pneumatic tyre, but, rather, as an alternative to the steel springs which will enable solid rubber tyres to be employed without the experiencing of undue discomfort.

The device has been in use in the United States now some eighteen months, both on touring cars and on commercial vehicles, it is said with complete success.

There can be no doubt such a device would be better than springs of steel and shock absorbers. It is, however, somewhat crude in design and capable of improvement.

LAMPS

Few car owners at the outset of their motor career pay much attention to the lamps on a car. To most of them a lamp is merely a brass case, with glass front, and burner inside; in reality it is a scientifically designed apparatus for producing and distributing light, reliable and economical in working, well designed and well made.

Paraffin, acetylene, and electric lamps are used on cars.

Plate I. shows the principal component parts of the C.A.V. electric lighting system, with the two side lamps, two head lamps, and one rear lamp or tail lamp.

As to external and general constructional design, lamps must have a good appearance. They occupy a position in the car so very prominently visible. They should be easy to clean, and have no projections, sharp angles, corners, or crannies to collect and conceal dirt.

Optically they should be perfect. The optical parts are the reflectors, glasses, and lenses.

In designing an electric lamp for motor car work there are many problems to be considered. To begin with, the designer is dealing with an entirely different set of conditions from those which occur with acetylene lamps. The object in view is to collect as many of the rays emitted from the source of light as possible and project them forward; not necessarily in a parallel beam like a searchlight, but so that the best driving light is obtained. It is not sufficient for safe driving to illuminate a narrow strip of road, for when rounding a curve the driver is apt to collide with objects on the part of the road which is not in the beam. Many of the mysterious collisions with cyclists and pedestrians are caused in this way.

The light of the acetylene flame or electric filament is given off in all directions; the object of the reflectors and glasses in the lamps is to direct it usefully in the desired direction. The reflectors are parabola

reflectors, with the light in the focus. The rays proceeding from the light striking this reflector are deflected and directed forward. A parallel beam is not of much use. The beam should spread fan-like to illuminate the roadside as well as the road itself. The C.A.V. lamp shown in Fig. 74, a diagram showing the spread of the light from the parabolic reflector, meets the case for electric light.

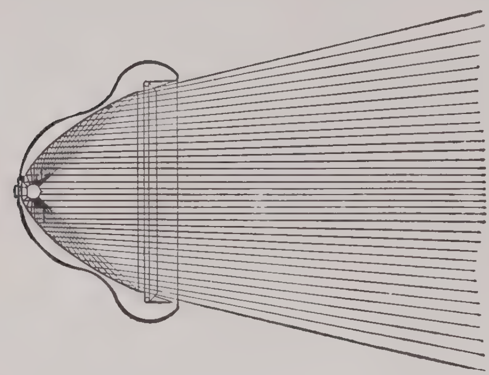


Fig. 74.

The acetylene lamps of Messrs. Rushmore & Co. may be taken as examples of that class. In order to get the best results short focal distances must be used, and to project a powerful beam of long range from an acetylene flame four things are necessary :

First.—The reflector (or equivalent optical device for projecting the rays) must receive the largest possible fraction of the total light from the flame.

Second.—The light so received must be *projected*, not absorbed by the surface of the reflector.

Third.—The beam must be slightly divergent but only so in the horizontal plane.

Fourth.—The projected beam must be non-scattering ; that is, when thrown upon a blank wall its outline must be sharply defined. If the outline is indefinite it indicates that some of the rays leave the main beam at an angle. Such scattering rays are quickly lost.

A parabolic silver-plated reflector intercepts a great number of rays from a flame at its focus, but it tarnishes so badly that it absorbs nearly all the light. The bull's-eye lens and its modification, the corrugated or Fresnal lens, absorb much of the light, and, as commercially manufactured, scatter the light around their edges, and therefore project beams of short range. As such lenses cannot be made of short focus, they are inefficient at best.

The foregoing objections are overcome in the lens mirror. This, as the name implies, is a bowl-shaped lens, silvered on the back, and formed of curves so proportioned as to compensate perfectly for the scattering effect of the plain spherical mirror. If the source of light were a geometrical point, the beam from a lens mirror would be perfectly parallel ; a mile distant it would be little larger than the lens, and it would lose intensity only by atmospheric absorption and dispersion. The spreading of the actual beam is due to the fact that the flame has a considerable area, so that only a single point of it can be in the geometrical focus. A beam from a correctly ground lens mirror gives, in fact, an inverted image of the flame itself, as may easily be seen by

directing it upon a blank wall, and it is therefore broadest where it strikes the road.

It is obvious that for equal diameters the lens closest to the flame will intercept the largest amount of light. The value of a short focal length, as it is called, is also apparent from the familiar law that "the intensity of the light is inversely as the square of the distance." That is, the closer the flame to the surface of the lens mirror, the greater will be the brilliancy of each individual projected ray. It follows that enlarging the flame does not increase the intensity of the beam, but only its breadth or spread. The mere employment of a large flame with a lens mirror of long focus does not produce a beam of the same intensity as is given by a shorter focal length and a small flame. The beam from the mirror of the shortest focal length will be the brightest under all conditions. For maximum range the lens mirror must be of large diameter also, since this gives a broad beam with little spread.

A short focal distance requires the lens to be of very tough glass to withstand the heat. Lenses are made of lead glass specially mixed to a special formula, and carefully annealed. Both they and their silver backing will resist any heat short of a flame playing directly on the glass.

The common spherical mirror, made cheaply of bent glass silvered on the back, has no true focus, and cannot reflect parallel rays.

This would be true even if the glass did not refract the light, for the only non-refracting mirror that can reflect parallel rays from a focus is the parabolic. But the effect of the glass is to scatter the rays in all directions, so that, no matter how strong the beam is close to the lamp its intensity is wasted a short distance away. In Fig. 75 is shown the effect of such a mirror on parallel rays coming from an external source,

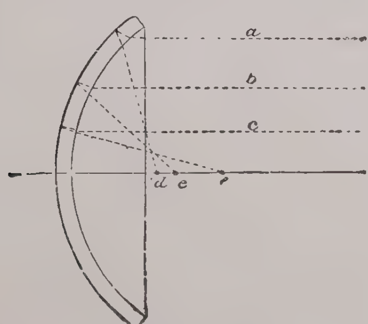


Fig. 75.

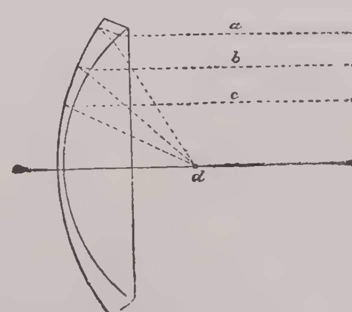


Fig. 76.

such as the sun. A ray, *a*, near the edge of the mirror, is powerfully refracted by the glass, then reflected and refracted again on emerging so that it reaches the axis at *d*. A ray, *b*, nearer the centre, cuts the axis at *e*. A ray, *c*, at *f*, etc.

To correct this defect of the common mirror, the Rushmore lens

mirror is ground to a graduated thickness which increases toward the edges of the mirror. The result is a varying refraction (see Fig. 76), which is so calculated as to produce exact parallelism of the rays issuing from the focus. Owing to the fact that glass may be ground with absolute precision, whereas it is impossible to form a sheet metal reflector to anything like a true curvature, it follows that this type of projector actually scatters the light far less than the most perfectly silvered metal reflector. Fig 77 shows the interior of the lamp with lens in section.

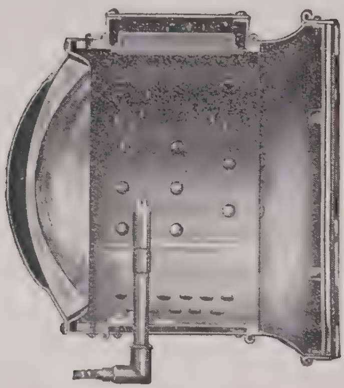


Fig. 77.—Section of Lamp.

In the Multiplex lens door head lights, Fig. 77A, the ordinary glass strips in the front door are replaced with heavier strips two inches wide which are flat on the rear side, while the front side is accurately ground and polished to a convex curvature. These lens strips spread the light out in a horizontal plane only as shown in Fig. 78, the beam giving a wide field and perfectly even illumination without spreading up or down.

Tests on a car driven sixty miles an hour in a strong wind have shown that flickering is completely eliminated, and the driver can always depend upon perfectly even illumination, and although when the car is standing still, with the doors open, the range is somewhat greater than with the doors closed and the beams spread out, still the complete absence of the flickering and dancing of the beams enables one to drive at high speed with greater comfort than with the plain glass door light.

The remarkable non-flickering effect is explained in Fig. 77A, in which 1, 2, 3, and 4 are diverging lens strips shown in section. Suppose a shield, or board 5, be placed temporarily in front of the two centre lens strips 2 and 3, so that the light from the lens mirror can escape only through strips 1 and 4. It will be seen that the light from strip 1 spreads out and covers the space between 6 and 7, while the light from strip 4 is likewise spread out over the same space; thus, no matter though one or more of the diverging strips may be covered up, the rectangular spreading beam remains in exactly the same position—covering more of the lens strips simply decreasing the intensity of the illumination. It will thus be seen that no matter how badly the flame may flicker, the light projected by the lens mirror passing through any of the diverging strips will be distributed evenly over the full width of the space 6 and 7.

In the Autoclipse lamp a convex lens is used in the front door, the combination giving a spreading ray and a parallel ray.

The special combination of the hyperbolic curve of the reflector and the plano-convex lens in Autoclipse lamps permits the use of a lens of large diameter and long focus in a comparatively small lamp. The

dotted lines at the back of the reflector in Fig. 79 show the depth of lamp that would be necessary to obtain a similarly powerful result if this patent hyperlenticular combination were not used.

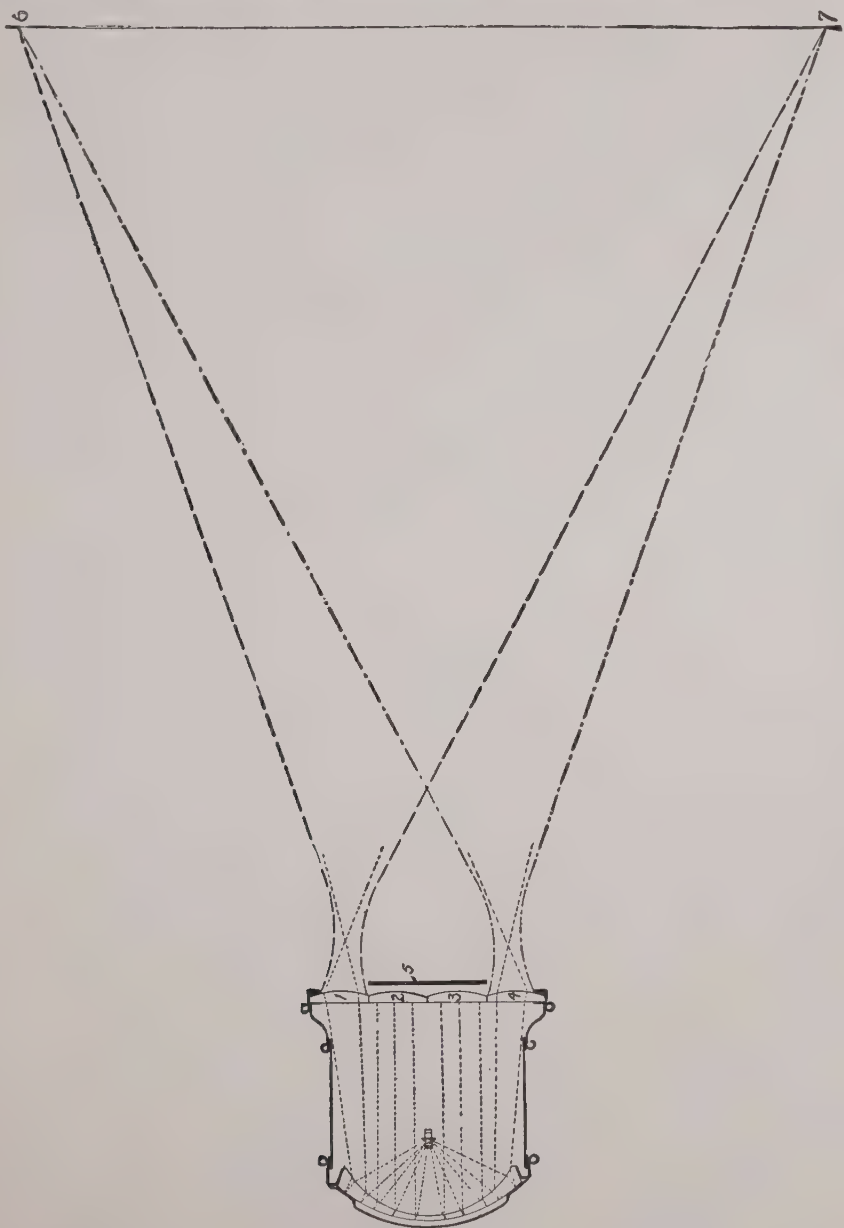


Fig. 77A.—Diagram of Head Light with a Lens Door.

The diffused, or short distance rays, produced by the light emanating from the front of the flame, are thrown directly on the plano-convex lens. These rays, magnified and rendered much clearer by the lens,

diffuse themselves at the sides of the car, as shown by the dotted lines R 2.

In the optical system the illumination results from the juxtaposition

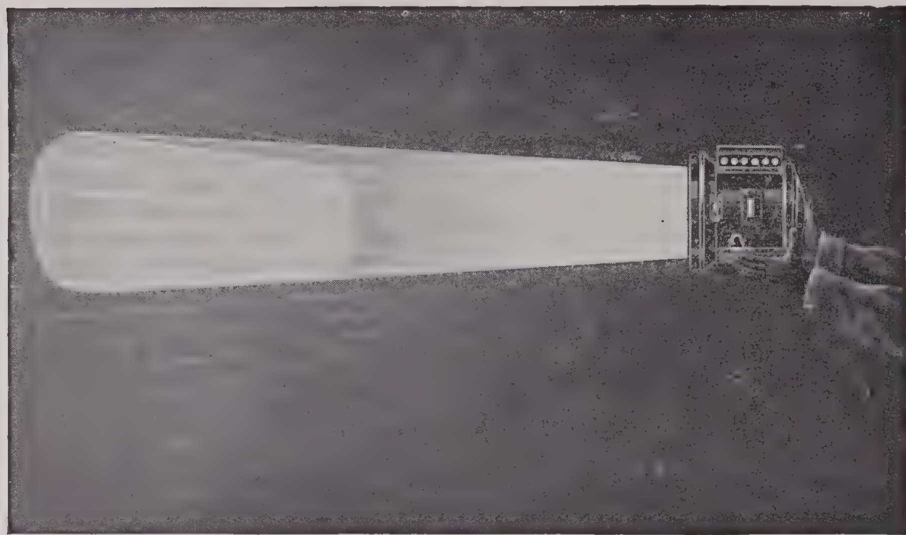


Fig. 78.—Beam of Head Light.

on the road of two sets of luminous rays; the parallel, or long distance rays, which are of great utility to the driver, are produced by the light emanating from the back of the flame F, and striking the hyperbolic

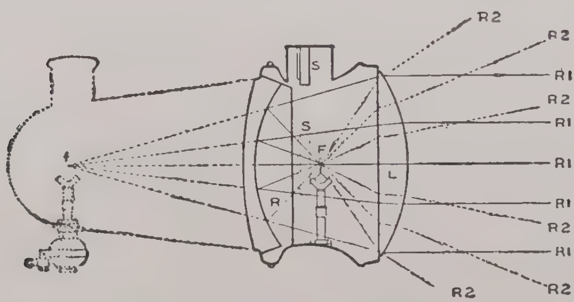


Fig. 79.—Autoclipse Lamp.

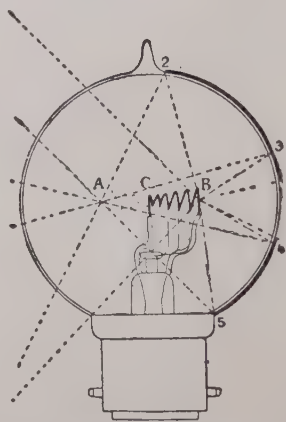


Fig. 80.—Electric Bulb.

reflector R, are thus reflected and directed against the plano-convex lens L, by which they are focussed and projected in long parallel rays of great penetrative power, as shown in the figure by the lines R 1.

For use with electric light a bulb with part of its outer surface silvered to form a reflector is used (see Fig. 80).

This special bulb increases the illuminating power of the lamp by

50 per cent. without any corresponding increase in current consumption.

The presence of the integral bulb in front of the reflecting mirror does not alter the projecting intensity of the lamp, owing to the small size of the bulb in comparison to the width of the mirror.

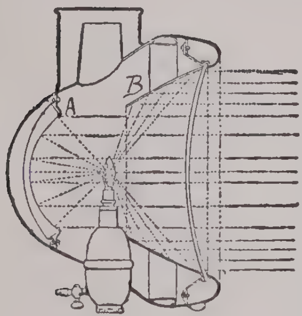


Fig. 81.—Paraffin Lamp.

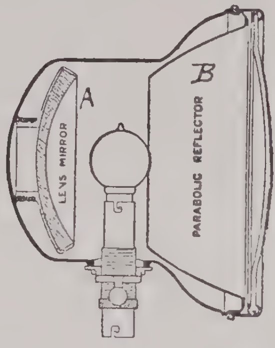


Fig. 81A.—Electric Lamp.

In fact, when the lamp is lighted, it is quite impossible to distinguish the bulb when one stands fifteen yards away from the lamp.

As the illustration shows, the filament CB, having its extremity in the centre of the bulb, gives in CA an image of itself by reflection on the silvered mirror, 2, 3, 4, 5. In this way a linear source of light is produced.

This linear source, due to the patented combination of a filament and a silvered bulb, gives a lighting power which is double the power of the filament itself.

Owing to the length of this source it has been possible to obtain long distance rays of a remarkable width, making them most suitable for motor car lighting.

This crescent acts as a shade, giving wide or short distance rays just in front of the car.

In another type of lamp we find a back reflector A and a front reflector B, as in Fig. 81 and 81 A, with the lamp between.

In Fig. 81 the path of the rays is shown. This combination gives very good results in forming a beam which illuminates both sides and front far and near.

In the paraffin side lamp shown in Fig. 82 the front mirror or reflector may be seen.

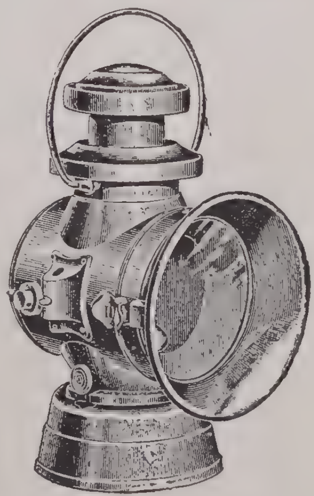


Fig. 82.—Side Light.

We have already described and fully illustrated electric generators. It remains to consider the acetylene generator. A substance compounded of carbon and lime called calcium carbide, when placed in water, or water dropped upon it, produces acetylene

gas (C_2H_2), a gas which burning in air produces a dazzling white light of great power. One pound of carbide generates $5\frac{3}{4}$ cubic feet of acetylene gas, and $14\frac{1}{2}$ cubic feet of acetylene gas weighs 1 lb., that is, one pound of carbide produces a little more than a third of a pound of gas.

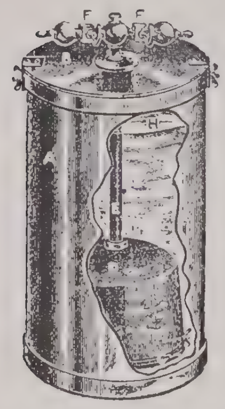
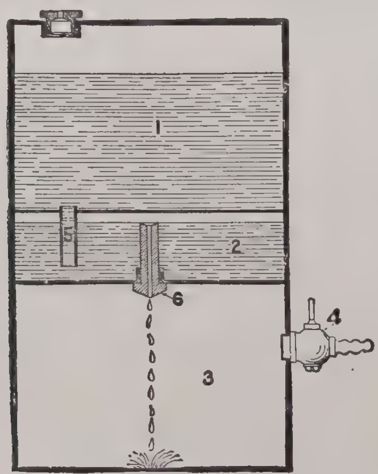


Fig. 83.—Diving Bell Generator.

The calorific value is 21,000 British thermal units per lb.

The generators are made up in two designs; one, in which the water comes in contact with the carbide bodily, and the regulation of the gas generation is by the gas pressure driving away or admitting more or less water, is known as the diving bell generator, shown in Fig. 83.

The carbide is contained in a chamber of diving bell shape D, perforated around the bottom to admit water. This bell has an outlet pipe E for the gas with stop cocks FF. The whole is contained in casing A with lid B, and partly filled with water to level H. Immediately the water comes in contact with the carbide, gas is generated, and if the supply tap is open this gas will pass on to the lamps. Should the tap be closed, the pressure exerted by the gas then acts inside the bell, and drives the water away from the carbide. Should the generation of gas still continue for some time, it will force its way through the water and escape into the atmosphere through a small vent hole, so that no dangerous pressure can develop within the generator. It will be



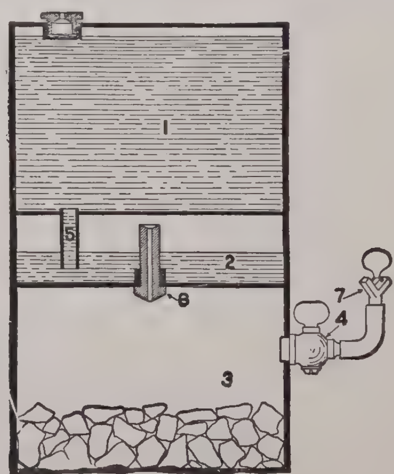


Fig. 84. Diagram of Drip Generator. Fig. 85.

seen that an automatic regulation of the gas is thereby obtained, because immediately more is being generated than can be used, the water is driven away from the carbide, but as soon as there is a demand for more gas the pressure inside the bell falls and water re-enters; thus

automatically the quantity of water is regulated and the gas produced as required.

In the "drip" type the water supply is held in the chamber above a vessel containing the carbide, and by a needle valve the water is allowed to drip into a perforated tube which is surrounded by the carbide. The bottom of the carbide vessel forms a grid or riddle through which the spent carbide falls.

The drip generator is shown in section in Figs. 84 and 85.

Suppose we have a vessel arranged as in Fig. 84, with a water tank 1, an intermediate chamber 2, and a bottom chamber 3, with an outlet 4, which may be closed. When water is poured into 1, it will run down into 2 through the tube 5 and will rise in 2 till it overflows the standpipe 6. If there is only atmospheric pressure in 3, the water will run down freely. If, however, 3 contains calcium carbide (see Fig. 85) the first few drops of water falling on the carbide will produce gas, the pressure of which, communicated to the chamber 2 through the hole in the standpipe 6, will force a portion of the water in 2 back through the pipe 5 to the tank so that the water level in 1 and 2 will take about the positions shown. The difference in water level between 1 and 2, or the "head" of the water, is then exactly equal to the gas pressure in 2 and 3, if both are measured, say, in ounces per square inch.

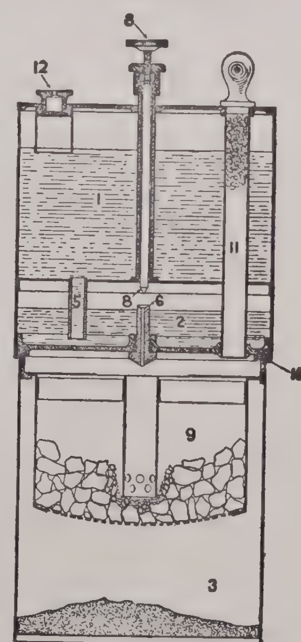


Fig. 86.—Generator.

If the outlet 4 be closed, the gas will then continue to hold the water back indefinitely. If a gas burner 7 be connected to 4, the gas will escape slowly, and as the pressure in 3 diminishes the water will slowly rise in 2 till it overflows 6 again, when the same process is repeated. The chamber 2 in the generator is called the automatic regulating chamber, and as long as carbide remains it will perform its functions in the manner indicated, permitting no water to fall upon the carbide except when the gas pressure in 3 has dropped below that sufficient to hold back the head of water in the tank. If the tank is full (as it should be) this head or height is approximately four inches, which gives the proper working pressure for the burners.

In Figs. 86 and 87 is shown the application of the principles to a shaking grate generator. The carbide is contained in a swinging basket 9, through the bottom of which the lime dust sifts when the basket is shaken. To give access to the carbide basket the generator is made in two parts, which are connected by a joint made gastight by a rubber washer 10. The water valve 8 is provided to shut off the flow of water to the generating

chamber when the bottom half is detached for recharging. In the actual generator, instead of taking the gas out from the side, it is carried up through pipe 11, which passes with gastight connections through the regulating chamber and tank, and is filled with horse hair which acts as a filter to prevent lime dust from being carried into the gas pipes. As this large tube is surrounded by the cool water in the tank, the gas is effectually cooled before passing to the burners. The tank is filled through filler cap 12.

The shaking grate or carbide basket is simply a square basket, suspended by its upper edge at two opposite points, and jarred constantly by a lead weight suspended from a spring. This weight is kept in motion by the slight vertical movement of the car when running, and by striking a corner of the carbide basket it gives the whole mass of carbide a sharp shock and the wire grate forming the bottom of the latter a slight horizontal motion, resembling that of a common ash sifter, which is found to be a complete preventative of the caking and clogging of the carbide experienced with other forms of generator. Cheap commercial lump carbide is used, giving the largest yield of gas per pound.

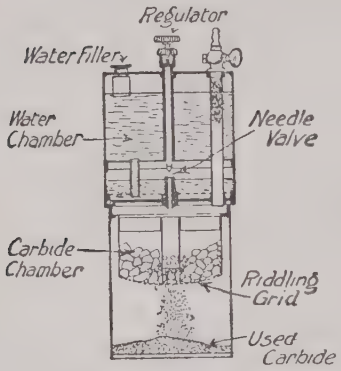


Fig. 87.—Shaking Grate Generator.

To charge, fill the basket with carbide (uncoated lumps) and fill the water tank to within 1 inch of the top as shown in Fig. 87. To operate, unscrew the water valve to full extent. Do not attempt to regulate the drip. To extinguish the lights close the water valve and pinch the rubber connections. Nothing else is necessary. It is only necessary to

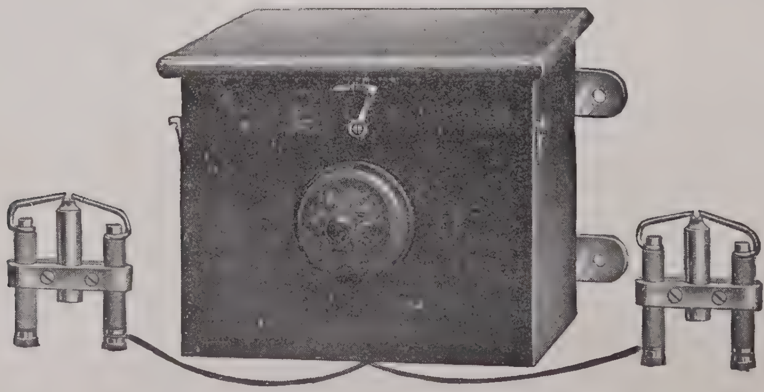


Fig. 88.—Electric Ignition for Acetylene Lamps.

recharge the generator when the carbide is exhausted. Until that occurs it will generate instantaneously as many times as required, no matter how long the time between one period of use and another.

The electric lamps may be lit simply by turning a switch. Acetylene requires to be lit by a match or flame or electric spark.

The Rushmore igniter, Fig. 88, consists of a battery and coil in a box in the dashboard; by pressing a button the driver can light up the head lights without moving from his seat.

Its action is simple and obvious. On the burner stem of the lamp is fitted a small attachment connected by one wire to the box on the dashboard. This box contains a miniature dry battery and sparking

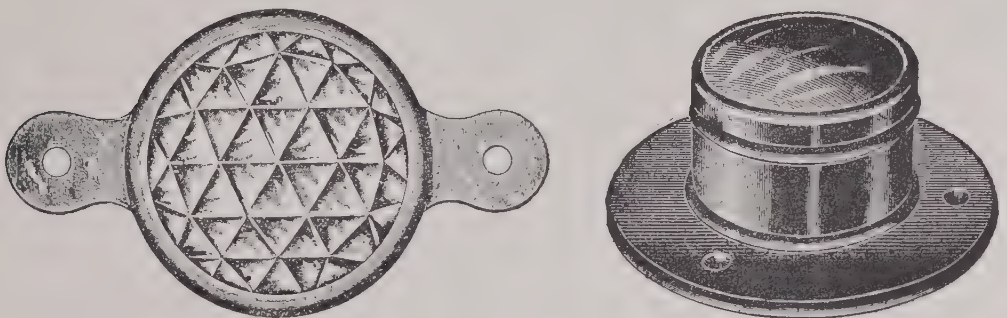


Fig. 89.—Reflector Rear Lights.

coil with a push button on the outside. When it is desired to light the lamps all that is necessary is to turn on the gas (we assume that the generator or D.A. cylinder is within reach of the driver or passenger, or can be so placed), press the button and the lamps light instantly.

Paraffin oil lamps are well understood and need not be noticed at length here. They are not powerful enough illuminators for head lights, but good enough for side and tail lights.

Reflector lights, Fig. 89, are sometimes used for rear lights ; these are not lamps. They shine by reflected light from the lamps of the approaching car ; that is, the driver of the overtaking motor car sees his own head light reflected back from the reflector. These reflectors may be used on horse drawn vehicles as a protection against being overtaken in the rear by a motor car.

Horns, whistles, etc., for warning on the road are necessary articles. They need not be elaborate engineering machines, although many of them are quite important machines. They exist in endless variety ; perhaps no accessory has attracted the attention of the amateur motor car engineer so much as the horn. In one large motor car catalogue of accessories the horn occupies no less than fourteen pages, illustrated by over one hundred illustrations.

They vary in price from *7s. 6d.* to £42, the cheaper ones being simple reed horns blown by squeezing a bulb of rubber. These can be made quite effective for the purpose and satisfy most people. A deep bass musical note will carry farther and be heard better among other sounds than a shrill note. The high-pitched note must be loud and

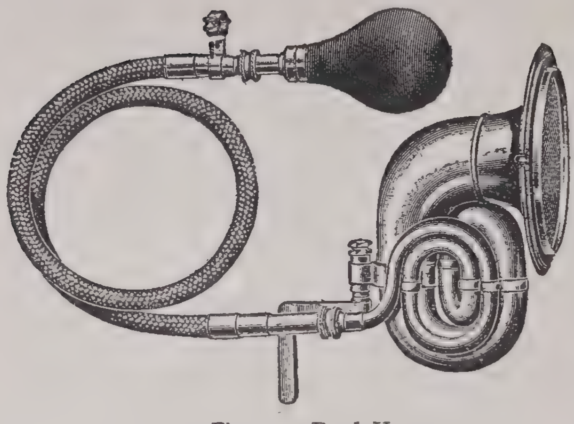


Fig. 90.—Reed Horn.

is disagreeable. A deep note, not very loud, and musical, is the ideal for road warning.

Of late, electrical horns have come into use, in which a harsh sound is produced by a series of raps upon a metal disc, and mechanical devices have been brought out to produce a noise in the same way. The exhaust has been applied to blow whistles, and so on in endless variety every device for producing a noise has been offered the motorist for use as a road warning. These mechanical and electrical devices are based on the same principles as the old clappers used in the fields by boys hired to scare away crows. The only advantages they seem to possess is that the driver is saved the trouble of squeezing the rubber bulb, and has only to press a button.

The simple horn is shown in Fig. 90. It has nothing about it very likely to go wrong. Most troubles arise from dust or dirt in the reed. The electrical and mechanical noise producers have many parts liable to go wrong and require special electrical knowledge to handle them well.

The reed of the simple horn is shown in Fig. 91. The tongue is easily damaged by rough usage; when correctly set it should be slightly apart from the box as shown. It can be cleaned by slipping a piece of thin paper across the opening.

Fig. 91.—Reed.

The electrical horn is shown in one form in Fig. 92. It resembles an induction coil. It has an electromagnet and a trembler make and brake which causes a hammering noise to be made upon a metal disc, dignified by the name of a sound diaphragm.

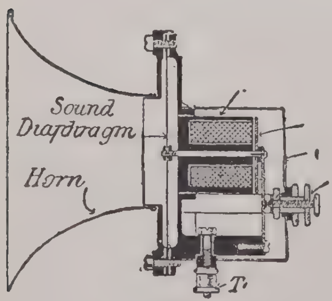


Fig. 92.—Electrical Horn.

In another form a little electric motor runs a ratchet wheel, the teeth of which clatter over a projection on the aforesaid sound diaphragm as in the crow-scaring clapper.

The choice of a horn is a matter of taste and expense—questions which concern the individual motorist only. But the sounds produced by horns are a matter of public interest. In many places they are a decided nuisance, though not all of them. Quite an effective horn for the purpose for which it is lawfully required is not unpleasant,

nor is it always in use, but chosen and used with some consideration for those on or near the roads other than motorists.

In tropical countries the rubber bulb cannot be used. Rubber is greedily eaten up by some tropical insects, and the heat and sunlight spoil it. Leather bulbs have then to be used.

SPEED INDICATORS AND MILEAGE RECORDERS

A speed indicator shows what speed the car wheels which drive it is making at any moment, by a pointer over a scale of miles per hour.

A mileage recorder shows on a series of dials the miles covered during a run of any period. Starting off in the morning, for instance, with the recorder set at zero, it may be read say at 12 or 1 o'clock, after running for say three hours; it might then show a distance covered of 58 miles, which would give an average speed of $58 \div 3 = 19\frac{1}{3}$ miles per hour.

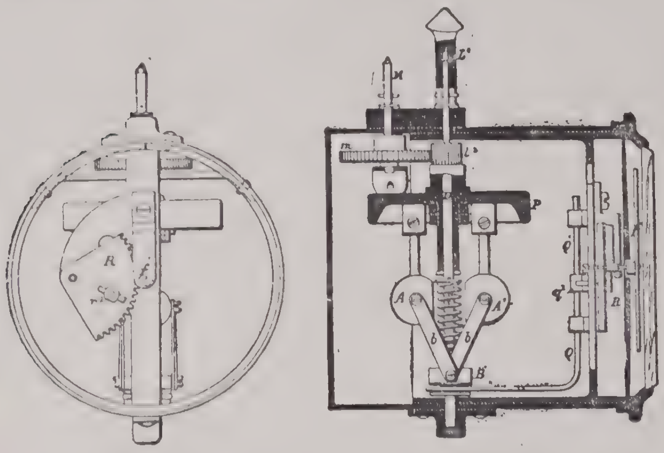
Some recorders cannot be set back to zero, in which case we take the reading as it stands before starting and deduct it from the reading taken when we wish to know the distance run. Say at 10 a.m. it reads 172 miles; at 1 p.m. we want to know how far we have run: we read the dials again and find it $= 220$ miles, and $220 - 172 = 48$ miles in three hours $= 16$ miles per hour average.

Both instruments are usually combined in one. Nearly all the mechanical speed and mileage indicators are constructed on the same principles, that of James Watts's pendulum centrifugal governor, and patented by Young for speed indicators about forty years ago. The electrical speed indicator is about as ancient as the mechanical one, and depends on the old law of Lenz; namely, any motion of a magnet near a conductor tends to drag the conductor along with the magnet, and vice versa any motion of the conductor tends to drag the magnet along with the conductor. Thus, if a magnet's poles are rotated in front of a copper disc, the disc will be dragged round in the direction of rotation, and if the drag of the disc is opposed by a hair spring its deflection will be proportional to the speed of the magnet's rotation.

In another electrical system of speed indicating a small magneto electric generator is used, driven by the wheel. The electromotive force is proportional to the speed, hence a voltmeter will read, if properly calibrated, miles per hour.

Young's mechanical speed indicator is shown in diagram Figs. 93 and 94, plan and elevation. The governor balls AA^1 are carried on the arms *bb*, pivoted to the sliding collar B, and hung from the flywheel P. When driven at L, the balls fly out by centrifugal force and pull up collar B against a spring shown. A fork rod *q* is lifted by the collar a distance proportional to the speed. This rod operates a toothed quadrant R, provided with a slot through which passes the pin r^2, the said pin being

capable of adjustment in the said slot, and being secured by means of a nut upon one end of it. The pin r^3 at its other end fits into a slotted arm q^2 fixed on the rod Q. By means of this arrangement motion is imparted by the sleeve or sliding bush B to the segment R, which actuates the index or pointer *f* by means of the pinion f^1; this gears with the toothed segment R, and is fixed on the spindle of the index.



Plan. Sectional Elevation.

Figs. 93 and 94.—Young's Mechanical Speed Indicator.

This instrument operates as follows: The carrier being placed upon either of the spindles, L or M is thrust against the centre of one end of the shaft whose speed is to be indicated, and the governor is thereby caused to rotate owing to the friction between the spindle L and the flywheel P; the balls A, A^1, flying outward by reason of the centrifugal force, draw the sleeve or sliding bush B towards the flywheel P, thereby compressing the spiral spring O, and at the same time acting upon the rod Q to cause it to move in the bearings. By this movement the slotted arm q^2 is caused to act upon the pin r^3, and thus turn the toothed segment R upon its pivot; the toothed segment acts upon the pinion f^1, thereby and moves the index or pointer *f*, so that it indicates upon the outer figures of the dial the number of revolutions per minute of the governor, and (if the carrier is upon the spindle L, as shown) of the shaft against which such carrier is thrust. If the carrier is placed upon the spindle M, the speed of the shaft against which it is thrust will be indicated upon the inner figures of the dial.

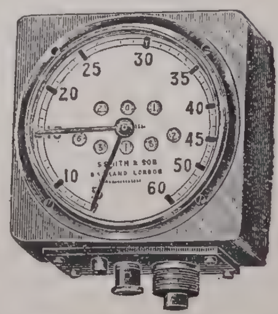


Fig. 95.—Speed Indicator and Recorder.

The motor car instrument has usually a scale of miles per hour on the outer circle and a maximum indicator hand to show miles per hour going at any moment and the maximum speed attained during the run; three dials to give the daily distance covered, and five or more dials giving the total mileage over a season, all shown in Fig. 95.

Sometimes a clock is combined as shown in Fig. 96, a very useful adjunct provided it is a good one.

The drive is by flexible shaft and geared wheels as shown in Fig. 97, as fitted to a motor bicycle.

A simple instrument fitted into the axle cap and geared direct to the hub is shown in Fig. 98.

This instrument adds whether going backwards or forwards, and is

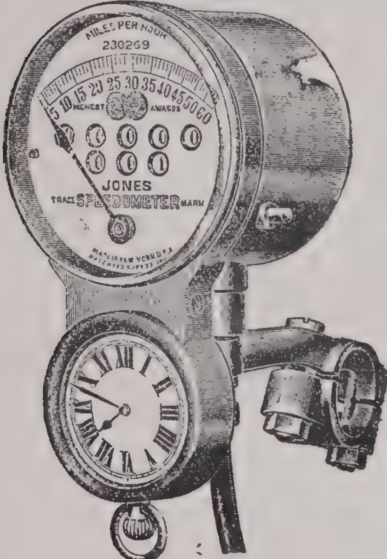


Fig. 96.
Speed Indicator and Register.

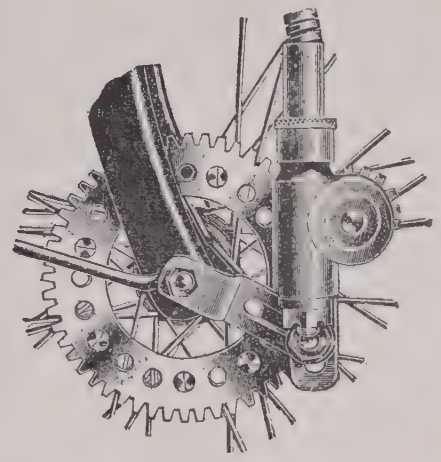


Fig. 97.
Speed Indicator Gear.

fitted inside the axle cap. It only projects very slightly, and can be sealed so that it cannot be tampered with.

Most mechanical speed indicators and distance recorders are good, durable, well-made instruments. The magnetic and electric instruments are liable to errors due to changes in themselves. Magnets weaken in time and cause the instrument to read too low, then when remagnetised they are too strong and read too high. On the whole the mechanical instrument is the best.

But no instrument yet invented can read either the correct speed or distance run, no matter how well made or designed. All these instruments read correctly is the number of turns made by the wheel of the car to which they are attached by driving gear; and they are designed on the false premises that the distance run is exactly proportional to the number of turns made by the car wheel.

Fig. 98.—Hub Register.

On a rigid smooth road with a hard unyielding wheel tyre, the revolutions of the road wheel would be very nearly proportional to the distance travelled. But with an uneven road and a yielding tyre the revolutions and distance are only approximately proportional.

The approximation may be quite near enough for practical purposes in some cases, while in others it is very wide of the truth, apart altogether from the perfection of the instrument.

Suppose the wheel to have a circumference of, say, three yards, it will make $1{,}760 \div 3 = 586{\cdot}6$ turns in a mile, from which value it is easy to gear up or down the instrument to read miles per hour and distance travelled.

But with a soft tyre on an uneven road it is not possible to determine the true circumference, or more properly, the rolling circle of the wheel; it varies with the load and the inflation pressure on the tyre. Hence all speedometers or odometers give readings which are only approximately correct.

The same thing applies to speed indicators for motor boats and ships. There is no such thing in existence as an instrument to measure speed and distance travelled accurately.

In ships we can ascertain the distance travelled by observations of the sun's altitude—that is, find the latitude and longitude every twenty-four hours.

On roads the only correct method for measuring speed and distance run is to count the milestones passed in a given time by a good stop watch. And to accurately test the speed of a motor boat the only true method is to time her on a measured sea mile.

Like horns, speedometers are made in great variety, being simple instruments with no specially new features in construction.

Although inaccurate, the speedometer is useful in giving the driver an idea as to his speed and distance travelled, while in the absence of the instrument he would have little or no means except guessing at his speed.

CHAPTER III

MOTOR CAR REPAIRS

THESE divide into three classes: first, roadside repairs, or repairs *en route*; second, home garage repairs; and third, professional repairs. The first are only such as can be carried out by the car owner or his chauffeur or both together. They generally consist of minor failures and defects in ignition, lubrication, carburettors, cooling devices, and such-like details. The second class are of a more serious nature and can be repaired only at the home garage if the owner or his chauffeur has some skill as a mechanic and the necessary tools; if he does not possess these, then the important repairs must go to the professional repairer.

With detachable wheels and detachable rims the necessity for road-side repairs to tyres is not now so urgent. The damaged tyre can be repaired either at the repair shop or at home, but where the tyre is not detachable and replaceable a roadside repair may be necessary; these are usually only of a temporary nature.

A burst cover can be remedied by lashing a gaiter over it. In addition to the gaiter outside, an inside canvas liner may also be applied. If neither of these can be applied, the inner tube may be wrapped in canvas where it comes under the burst so as to protect the tube (Fig. 99).

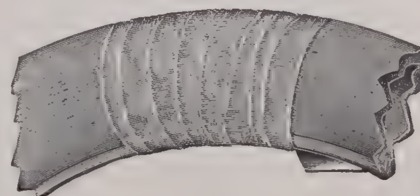


Fig. 99.

Inner tubes and surface cuts when repaired should be vulcanised. Small handy vulcanisers are now to be had with full instructions for use, for the garage, and for carrying on the car for repairs *en route*.

In repairing rubber tyres or covers the rubber is applied in a plastic condition like putty, to make good the defect. This plastic rubber is then converted into an elastic and resilient rubber by vulcanising; the patch becomes an integral part of the tyre and of the same material.

A repair by the Harvey Frost process is effected by the application to the damaged part of sufficient rubber in a plastic or putty-like condi-

tion, the portion under repair is then subjected to a certain temperature by a vulcaniser, an instrument whereby the plastic rubber is by prolonged heating converted into the resilient condition.

The vulcaniser is, in fact, a small steam boiler of convenient shape

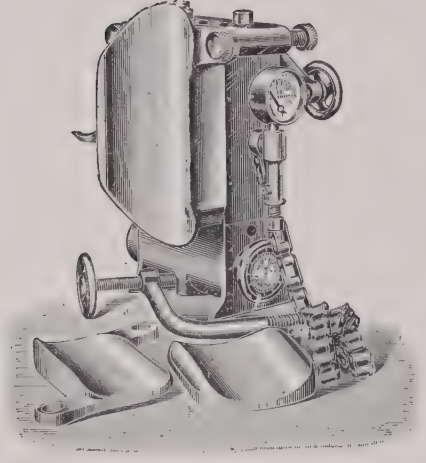


Fig. 100.

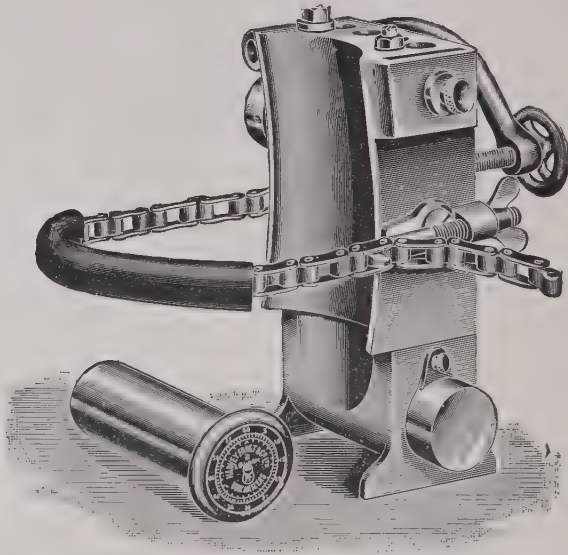


Fig. 100A

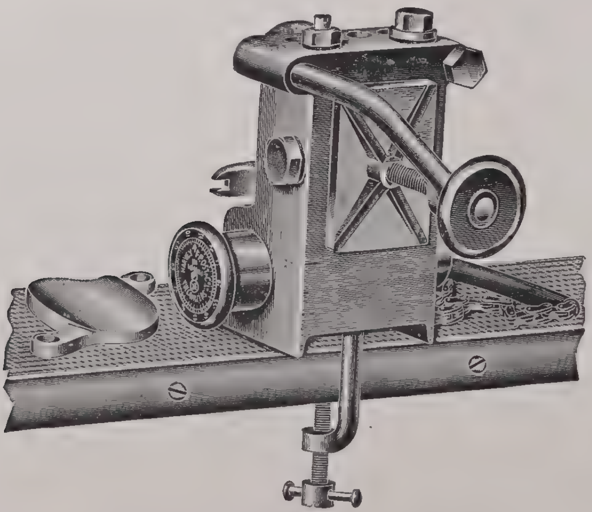


Fig. 100B.—Harvey Frost Vulcanisers.

for application of heat to the tyres. The portable forms are shown in Figs. 100, 100A, 100B called the "Car" vulcaniser.

The H.F. "Car" vulcanisers, Figs. 100, 100A, 100B are steam generators of the tubular type manufactured of gun metal, and heated by means of

either methylated spirit or gas burners, either of which is under the absolute control of the operator. Though they embody all the essential features of the large vulcanising plants used in rubber and tyre factories, they are so compact and light in weight that they can be carried in any odd corner of the car. They are so simple that a car owner or his chauffeur by their aid can successfully treat his tyres (covers or tubes) without previous practice or instruction, and being self-contained can be used in the garage or on the roadside.

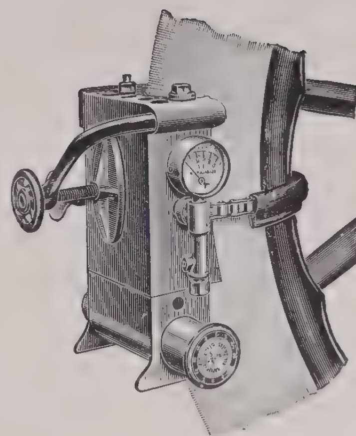


Fig. 101.—Tyre Repairer.

The "Car" is the most popular of the H.F. portable vulcanisers, upwards of 25,000 being in use all over the world with unqualified success. By the aid of this appliance, repairs can be undertaken to any and every pattern, size, and contour of tyre. The illustrations 100, 100A show the curved portion for cover repairs, the flat side being used for inner tubes. Covers may be repaired without removing the tyre from the wheel, the vulcaniser being attached in the manner shown in Fig. 101.

The use of the flat side for repairing a puncture or burst tube is shown in Fig. 100B.

Fig. 102 shows the vulcaniser mounted on a stand for use in a private garage.

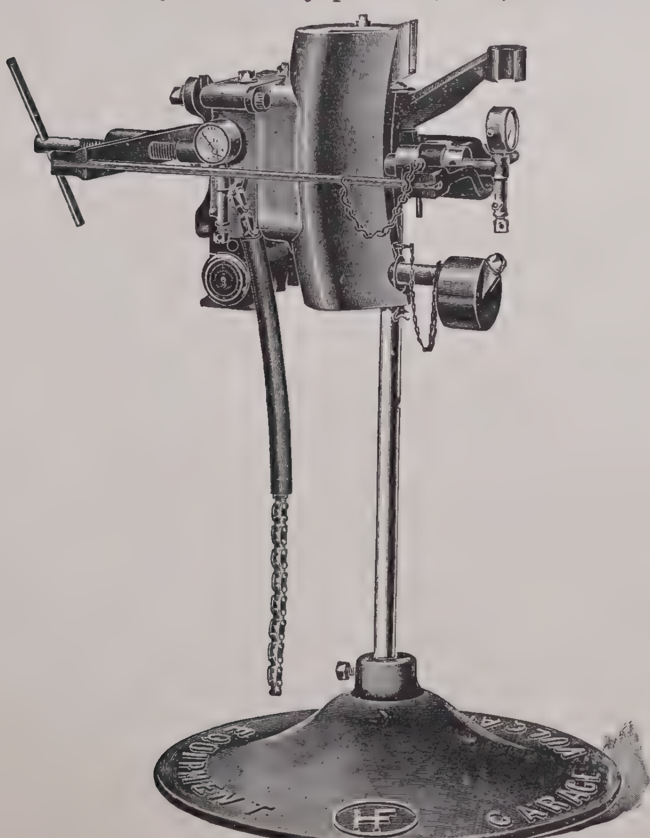


Fig. 102.—Garage Vulcaniser.

When a car owner, especially one living at a distance from repair shops, has to undertake the various repairs so often needed by covers and tubes, it necessitates his having a plant which will repair

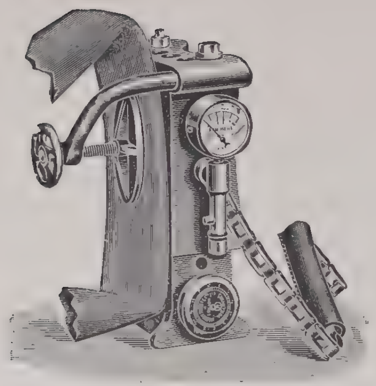


Fig. 103.—Inner Tube Repairer.

punctured and burst tubes, surface cuts in covers, and complete bursts in tyres. These repairs and others are all provided for in the garage equipment, and arranged for in such a manner that any one of ordinary common sense can carry out efficient and lasting repairs by simply following the printed instructions.

It will be seen in the illustration, Fig. 102, that the equipment consists of two vulcanisers, so arranged that either can be used separately or both simultaneously. The internal heat necessary for repairing the damage to canvas foundation is obtained from the portion of the appliance which is shaped to fit the inside of the tyre, while the external repairs are executed by the " Car " vulcaniser, which is included in, and forms part of, the equipment.

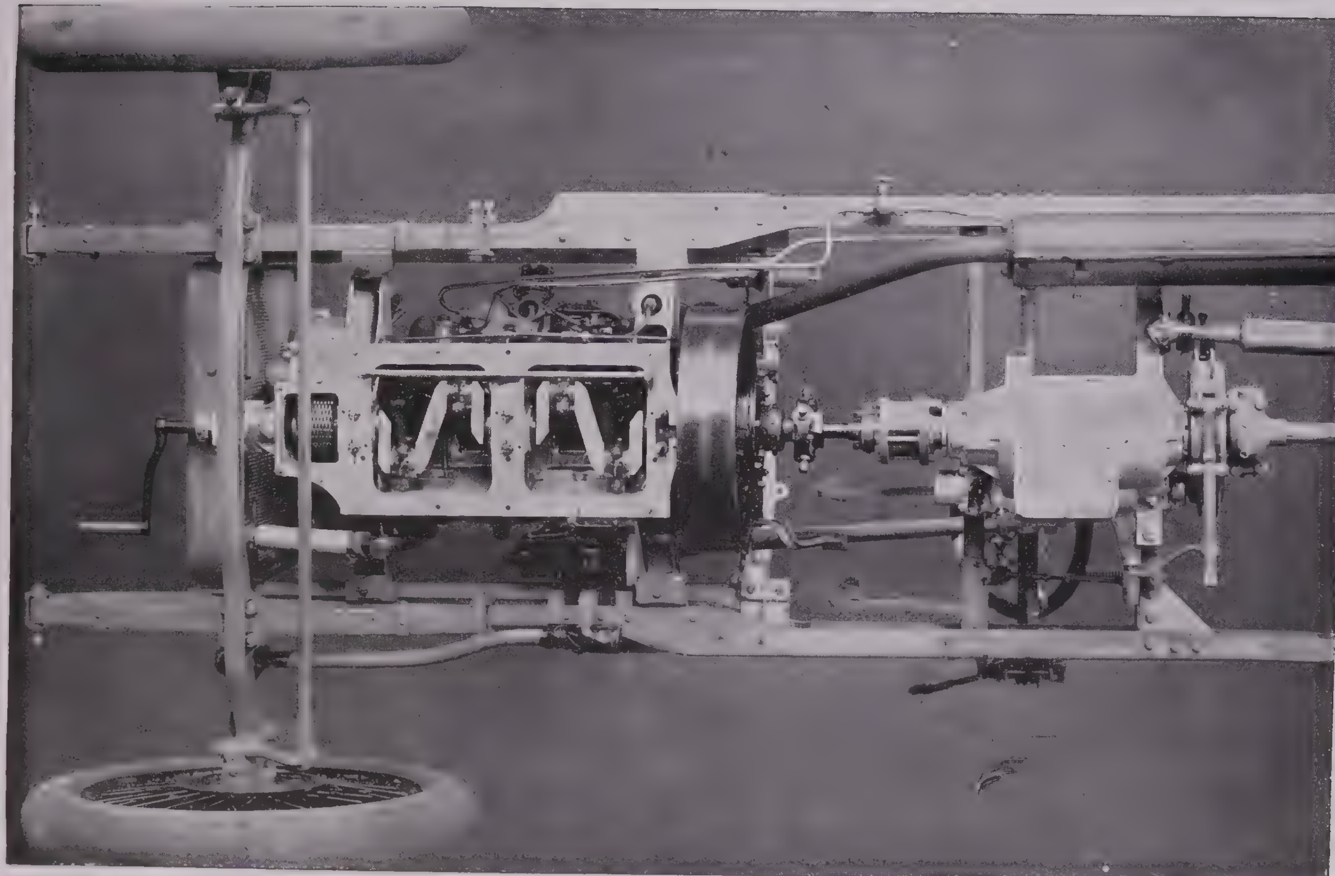
Each part is separately heated and separately controlled, and each is fitted with quick heating tubular steam generators, the heat being supplied and maintained by spirit burners provided with suitable regulators. Steam pressure gauges and safety valves are fitted to each, and every means is provided to enable the operator to obtain the correct heat and surface pressure. The ease with which the appliance can be adapted to various forms of repair work is an extremely important and valuable asset.

With the internal or convex vulcaniser, a repair of nine to ten inches can be executed to the canvas fabric or foundation of the cover.

The external or concave vulcaniser is used for repairing the surface either on the sides or on the tread, and as the heating surface is formed by a mould attached to the vulcaniser, and these moulds (or adapters) may be had for every pattern and contour of cover, every kind of tyre may be repaired.

The portable (or " Car ") vulcaniser will repair cuts in a tyre when it is *in situ*, and without removal from the wheel. When treating covers off the wheel, they are placed between both vulcanisers, and by the aid of the screw clamp the two appliances act as a vice, and so secure the necessary contact and pressure.

In repairing a complete burst, both vulcanisers are brought into requisition, the cover is placed between them, and by means of the screw clamp it is held firmly and evenly between the two appliances, the combined heat of which vulcanises the interior canvas and exterior rubber in one operation. In repairing an interior defect, it is necessary to bind the cover round the internal (or convex) vulcaniser, and to enable this to be done easily the equipment is provided with a means for holding the vulcaniser in a horizontal position. This also serves as an



VIEW FROM PIT OF UNDERSIDE OF WOLSELEY 20 HORSE-POWER CHASSIS, WITH LOWER HALF OF CRANK CASE REMOVED.

excellent mandrel for supporting the cover when preparing a surface cut for treatment.

Inner tube repairs are carried out on the external or "Car" vulcaniser, the flat surface of which is used, and the tube held against it by means of the tube press, Fig. 103. By removing the curved surface mould and affixing the extra tube press (provided), two tubes may be repaired at one time.

The plastic rubber is a scientifically manufactured material very *accurately* compounded, therefore to get the best results repairs should be *accurately* carried out according to instructions, and vulcanised with strict adherence to the time table as under. H.F. "Plastene" is blue in colour—vulcanising black.

It should be borne in mind that the length of time for curing is not governed by the width or the length of the repair, but by the depth of the new material introduced.

Times for vulcanising tube repairs at 45 lb. per square inch steam pressure, which must be uniformly maintained during the whole operation:

Thickness.	Time.
$\frac{1}{16}$ inch	7 minutes.
$\frac{1}{12}$,,	8 ,,
$\frac{1}{10}$,,	10 ,,
$\frac{1}{8}$,,	13 ,,
$\frac{1}{6}$,,	15 ,,

The dial attached on the end of the burner sleeve is for indicating when the repairs should be removed from the vulcaniser. For instance, say a repair was placed on the vulcaniser at five minutes after the hour, and the time for vulcanising was ten minutes, the dial should be set at fifteen, thus indicating the number of minutes after the hour the repair should be taken off.

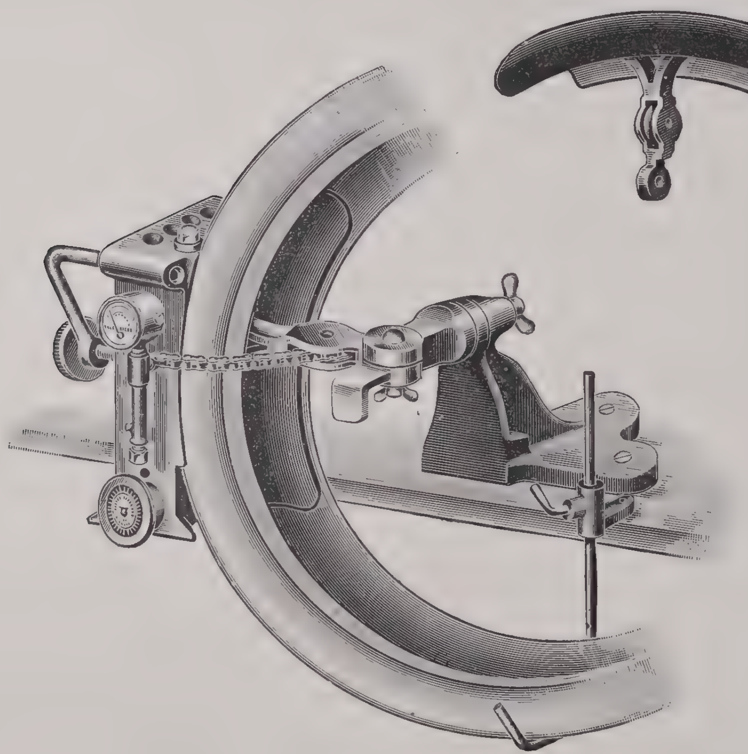
Test the part vulcanised by pressing the thumb nail into it. If it is responsive and elastic to the touch, and resembles the rest of the tyre in this respect, it is perfectly vulcanised. If, however, it clearly retains the mark of the nail, it is under vulcanised and should be again applied to the vulcaniser for a short time. If it is hard, brittle, and not responsive to the touch, it is over-vulcanised—*this should be most carefully guarded against.*

Probably the chief thing to guard against in doing vulcanised repairs is what is commonly termed "gasing," which in reality is the penetration into the repair of foreign gases, causing it to become porous. These gases may be created either through the tyre being damp, and the dampness giving off steam when the tyre or tube is being vulcanised, or they may result from air secreted in some part of the tyre adjoining the part being treated, and which has expanded under heat. Or it might even be naphtha gas, and, if so, this would be due to the flux not

being dry enough when the repair is applied to the vulcaniser. All these gases have a similar effect, and it is difficult to attribute "gasing" to one or the other.

For workshop use a shell mandrel is supplied with a bench fixture which enables the user to repair covers when off the wheels as shown in Fig. 104, and the shell in Fig. 105. This makes the vulcaniser useful both in the garage and on the road.

Should the repair be too long to be treated in one operation, it can



Figs. 104 and 105.—Vulcanising Repair at Bench.

be done in two or even more, but it is preferable in this case to place a piece of paper or some other non-conducting material at the end of the part being cured, so that in the second operation that which was partly vulcanised the first time is wholly vulcanised in the second operation. This prevents what would otherwise be the over-curing of that part. Also it will be found more convenient to prepare only that portion which can be treated in one operation.

When dealing with extra large repairs, the H.F. tube clips should be used to hold the tube in proper shape.

In dealing with bursts where a portion of the tube is missing, a somewhat different method is adopted. Instead of attempting to fill in the

hole with unvulcanised compound, it is simpler and more economical to replace the missing portion with a piece of rubber, and odd pieces of old tubes can be utilised for this purpose. The first step is to find a piece of old tubing about the same thickness as the tube needing repair, and to cut a piece from it exactly the same size and shape as the burst and fit it into the opening with plastene.

When repairing tyres off the wheels it is necessary to have a mandrel which will fit inside the cover so that the pressure can be secured. The H.F. shell mandrel and bench support is an extremely useful addition to any H.F. vulcaniser, and adds very much to the ease with which both covers and tubes can be prepared and vulcanised.

Extensive tyre and cover repairs we need not enter upon here. These are usually sent to the professional repairer. The repairs of a small kind so often required are all within the powers of the chauffeur. Surface cuts on covers should be immediately attended to; these, and bursts in the cover, are the most commonly required repairs, and need not be sent to a repair shop if the owner fits out his own garage with these simple vulcanisers, and has a chauffeur who has learnt to use the necessary tools.

Tyres should be examined immediately after the car is put up for the night after a run, and all cuts and other damages marked by chalk. It is then a question to decide whether to repair them there and then or to go on until some more serious damage occurs. But if time permits all superficial damages should be repaired at once. They soon develop into worse faults, especially if the rubber is cut through and the canvas exposed.

For repairing inner tubes the motorist may obtain a solution of pure rubber and especially prepared patches. In using these the tube where the repair is to be made must be clean. Cleanliness is the first condition of successful patching. The solution and the patch must be applied without touching the adhering surface with the fingers. However clean the hands may be, there is always some greasy moisture on most skins. The surface of the tube should be cleaned by a solution supplied for the purpose and roughened slightly by a scratch brush, and the solution applied by a slip of wood or an old paper knife.

THE PARSONS RAPID REPAIR KIT

Sticky tape, solutions of rubber and patches are messy and difficult to handle on road repairs, and can be properly dealt with only by skilled workmen. Several propositions for repairing by other means have been brought forth. The Parsons is one of these, and offers a more permanent repair. The repair is made by a soft metal button or plug, Fig. 106, which is covered by rubber all over. This plug—which may be described as a new kind of patch—is placed in the puncture, and is then

Fig. 106.

pressed or squeezed with a pair of specially constructed pliers, Fig. 107. The operation takes less than one minute; and when the plug is properly compressed, it will never leak. The repair is absolute and permanent.

When compressed, the metal skeleton in the Parsons plug has ten times the tensile strength necessary to keep the puncture closed. It has no sharp edges. The rubber cover prevents any possible chafing

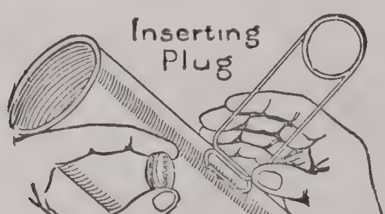
Fig. 107. Parsons Repair Kit. Fig. 108

of the tube. If properly compressed, leakage and injury to the tube are alike impossible.

No skill is required to carry out a repair with the Parsons rapid repair kit. A boy can do the work as well as an experienced mechanic.

How to Proceed with a Repair

First.—Push the pointed end of the cutting tool through the puncture and screw down the cutter, so making a clean hole as in Fig. 108.



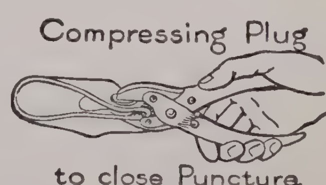


Fig. 109. Repairing a Puncture. Fig. 110.

Second.—Insert the ends of the wire spreader into the hole made by the above process; then by compressing the spreader, stretch the hole as in Fig. 109.

Insert the plug so that the printed side is on top and withdraw the

spreader; then twist the plug round to make sure that the edges of the punctured part of the tube are well within the plug.

Third.—Bring the near side of the tube towards you, so that the plug is carried to the near edge and placed directly under the discs on the jaws of the pliers (see Fig. 110). Grip the handles of the pliers firmly, closing the jaws and clamping the plug in the tube. Then reverse the operation, taking the plug to the farther side of the tube and applying the pliers from that side. The repair is then complete, Fig. 111. It is essential to use considerable force to compress the plug properly.

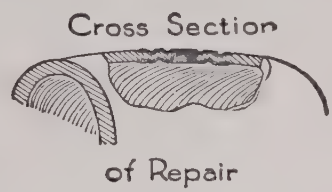


Fig. 111.

After the repair has been effected care must be taken not to stretch the tube in the vicinity of the repaired puncture.

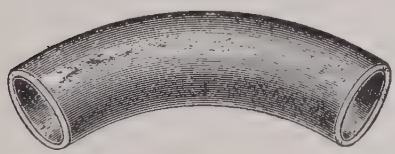


Fig. 112.—Inner Tube Section for Repairs.

Sometimes an inner tube is so badly damaged as to require cutting out the part entirely and the insertion of a new section. Spare sections may be covered as shown in Fig. 112, and with a little skill and the necessary rubber solution these may be joined up to form a complete tyre tube. The most important point to attend to is adjusting the section to the same length as that cut out and the cleaning of edges to be joined.

For road repairs, gaiters and plasters are applied to the damaged outer tyres as a temporary cure to take the car home or to a garage.

A leather gaiter is shown in Fig. 113 which can be firmly laced by a leather lace over the burst or cut. Another type is that shown in Fig. 114, the sleeve gaiter. These should be laced up when the inner tube is only partially inflated, then when fully inflated the gaiter will fit tightly. A plaster is used for more permanent cures. The tyre must be removed in order to apply them as they are applied to the inside of the tyre. One is shown in Fig. 115. It is built of several thicknesses of prepared canvas and rubber and moulded to the shape of the inside of the cover, to fit the beaded edge.

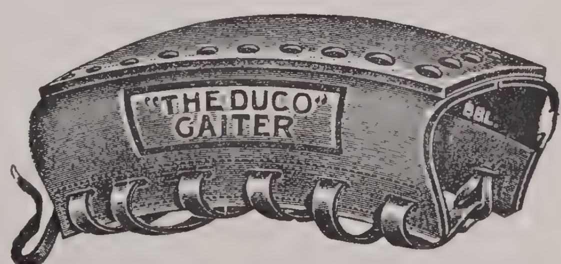


Fig. 113.—Gaiter for Cover Repair.

Another patch is shown in Fig. 116, one applied, the other being put in place over a burst. Good patches cost about two to four shillings

made up of proper shape and form for inside of tyre, and enable a good roadside repair to be made and the journey continued.

To remove a tyre several kinds of levers are supplied. The simplest is shown in Fig. 117 at 6, made of good spring tempered steel. Its use is shown in the five figures.

In 1 the security bolts are first slacked and the winged nuts run back, the edge of the cover is then pushed back and the flat end of the lever inserted as shown at 1; by then prising up the cover is lifted out as shown at 2, then by depressing the lever we arrive at position 3, the

Fig. 114.

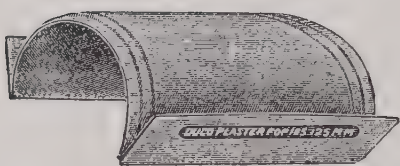


Fig. 115. Gaiter and Patches. Fig. 116.

lever having made a half revolution between positions 1 and 2; by pressing with the hand the operation is much easier. Care must be taken to remove the external parts of the air tube valve before beginning operations.

Two levers may be applied about six inches apart on each side of a rim bolt, and the levering process repeated at intervals round the rim until all the edge is lifted over the rim.

If the inner tube sticks to the tyre it should be loosened by a little petrol.

In replacing the tyre, care must be taken to attend to the air valve tube and the security bolts. The tyre is then levered into place again by using the hooked end of lever as shown in Fig. 117, 4. And in using the lever it must not be allowed to squeeze into the inner tube as shown in 5. Care and good judgment are necessary in the whole operation.

Pronged levers are used with advantage. They are operated on a large length of the edge by one hand only. Fig. 118 shows one with two small horns on each prong to take the tyre edge.

Another is shown in Fig. 119, adaptable to any size tyre; this is a popular type.

A double lever with a hinge is shown in Fig. 120. The left figure shows it removing the tyre, the right replacing it. This lever is the

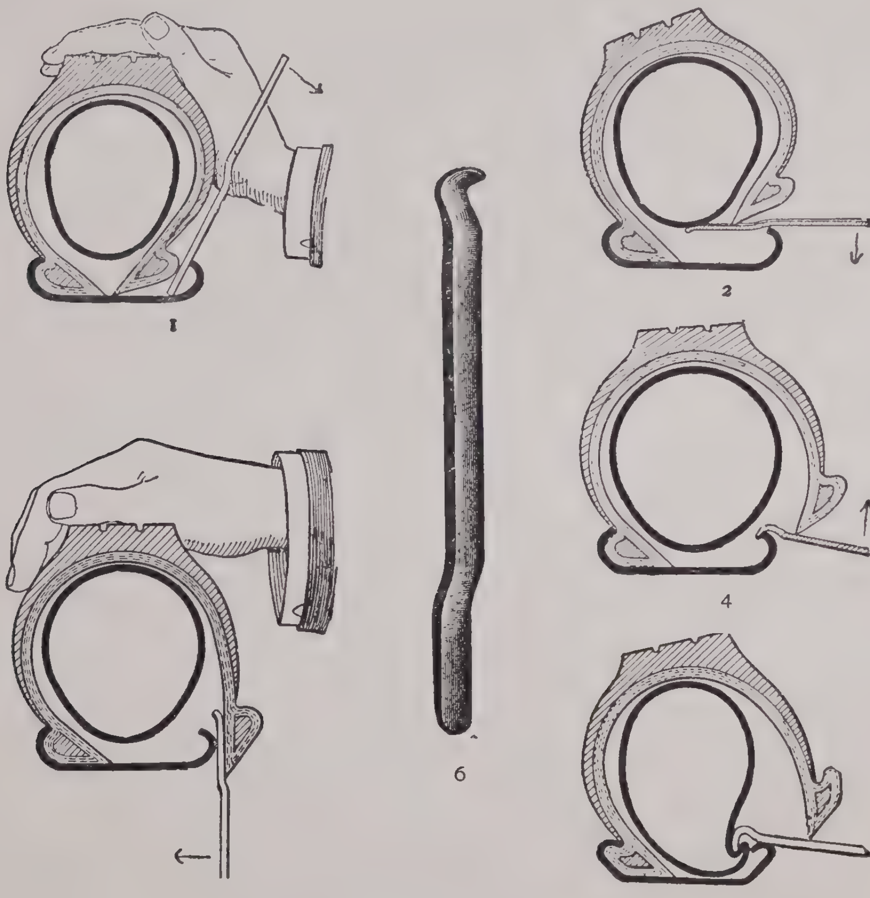


Fig. 117.—Removing and Replacing Tyres.

best; it gives great power without so much exertion as the plain lever requires. Fig. 121 shows a lighter make for small tyres.

Inner tubes are now made in straight lengths with a butt end so that they can be readily taken off and on and adjusted to correct length. A tube of this kind is shown in Fig. 122. This greatly facilitates repairing.

Other tyre troubles which may require attention on the road occur at the air valves. The air valve is not a complicated affair, but it has many parts, and as they will be referred to in discussing the repairs a

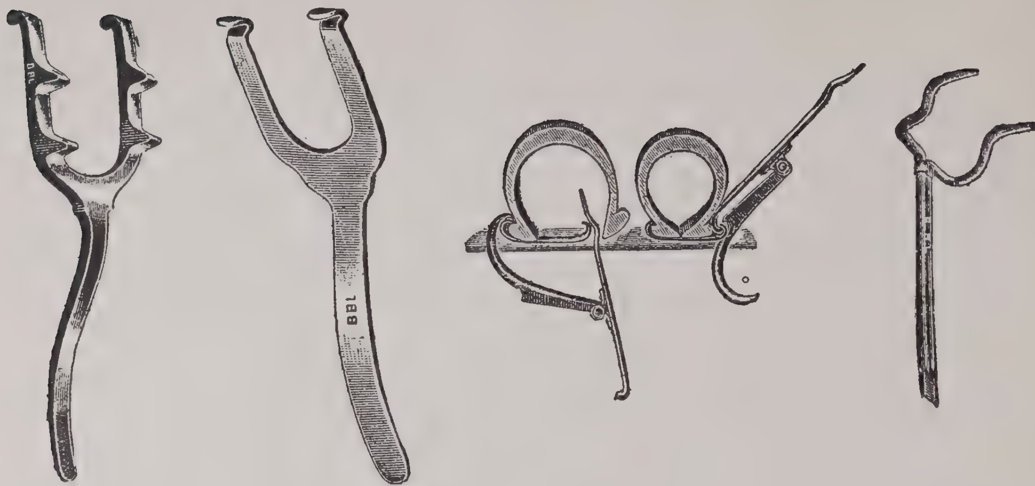


Fig. 118. Fig. 119. Fig. 120. Fig. 121.
Levers for Removing and Replacing Tyres.

figure is given here of the air valve dissected and its parts lettered, and a table given of their names (Fig. 123):

A, Oval washer, brass.	I, Centre screw, milled.
B, Hexagon nut.	K, Cap and deflator.
C, Large rubber washer,	L, Centre stem.
D, Stem.	M, Small rubber washer.
E, Metal washer.	N, Rubber headed pin.
F, Milled nut.	O, Rubber disc for deflator cap.
GH, Large dust cap.	

The stem is usually made long enough for wood rims, and hence is too long for wire wheels, thus leaving much of the thread screw exposed to dirt as the dust cap is not long enough to cover it all. A short piece of brass tube may be cut off to form a sleeve to cover the exposed part;

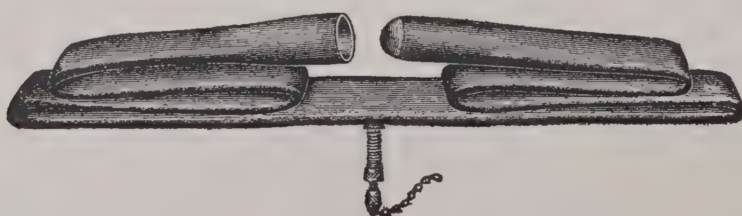


Fig. 122.—Spare Inner Tube.

this will be held in place by the dust cap pressing it against the milled nut G.

Many troubles arise from leaky valve caps K screwed on to L. The cap has usually a small rubber disc inside which is intended to close the hole in L. Sometimes this rubber gets cut or squeezed and frayed,

so that it does not properly close L, and leakage occurs. A small nicely flattened lead disc is better, or a good leather disc. The leather may be put in on top of the rubber disc; these prevent all troubles of the kind. Care should also be taken to give several strokes to the pump every time before attaching the tube to the air valve so as to blow out any dust which may be in the connecting tube or pump junctions.

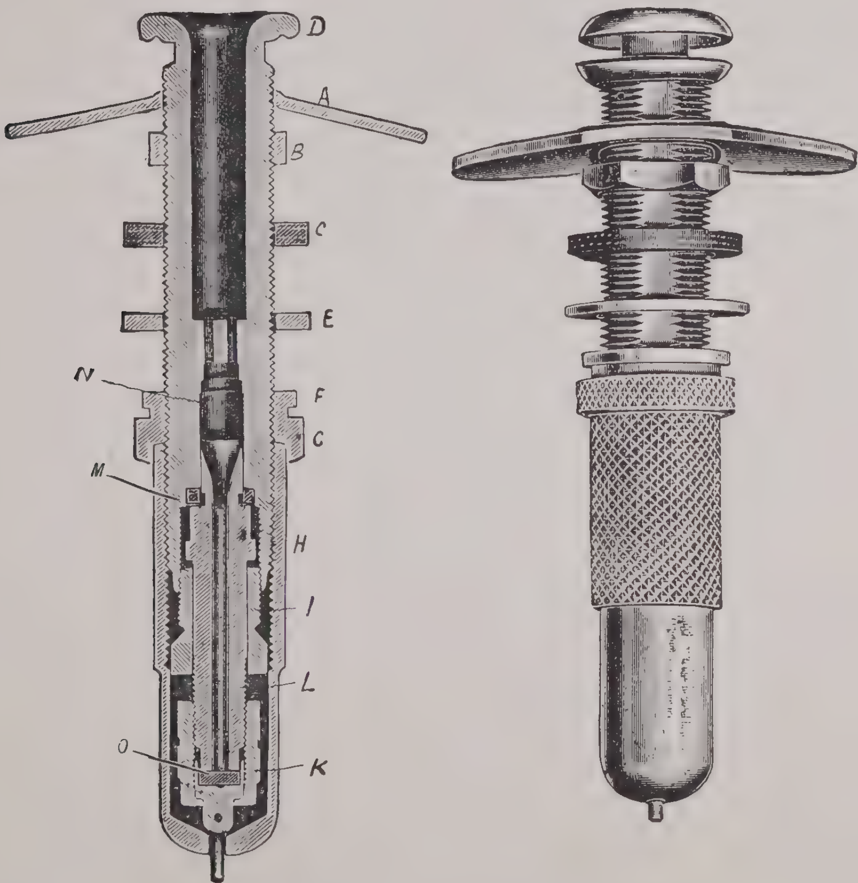


Fig. 123.—Tyre Air Valve.

Oil sometimes gets into the pump connecting tube and forms a sticky, gummy substance on the inside. This stuff in a small quantity gets into the valves and causes leakage. The remedy is to clean or put in new valve rubbers, and to use a new connecting tube.

Often the tyre is supposed to be punctured when the fault is really in the valve. It is, therefore, safer to first examine the valve before proceeding to take off the tyre. When a puncture occurs the tyre collapses suddenly with a hissing sound. A slow going down of the tyre indicates a valve leakage.

CARE OF TYRES

Many tyre damages are due to bad driving and carelessness or deficient knowledge. Tyres are often damaged by rubbing against the kerb. The side of a tyre is not protected, for it is not supposed to rub against a rough kerb. Once scraped along a kerb, water gets into the canvas and as a result rot is started which ruins the cover. Oil is also bad for tyres and should be cleaned off at once.

In winter time or when the car is to be laid up for a time, never allow it to stand on the tyres. It should be jacked up and stood upon four trestles on the axles near the wheels. The tyres should not be deflated; but if the car is to be stored for a long time it is better to remove the tyres and have them put into good repair, cleaned and

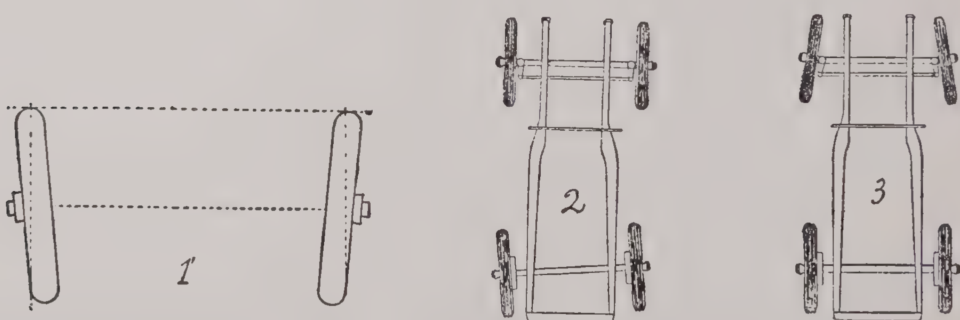


Fig. 124.—Wheels out of Alignment.

properly stored away in a dark cool place. Inner tubes keep better when partially inflated.

Rims are often damaged when a tyre suddenly fails. They should be carefully inspected and any damages done properly remedied by a good blacksmith or mechanic. The rim is made of sheet steel, and although stiff and strong it can be bent and twisted by coming on to the road.

Another source of undue wear on tyres is incorrect alignment. Three figures (Fig. 124) show this defect. First, wheels at a vertical angle, and not both at same angle. Front wheels at a vertical angle cause difficult steering, especially so with square tread tyres. In the second figure the axles are out of line, and in third figure the front wheels make a horizontal angle to each other. This fault is very severe on front tyres. The owner or chauffeur may not be capable of repairing these defects, but he should be able to discover them. They may be observed by a trained eye, but can also be found by a stretched line, or by tape measurements.

Care of Tyres

Tyres and the Driver

Nothing shortens the life of tyres more than careless and bad driving. A careless driver will run his tyres at full speed over new road metal, causing many surface cuts in the tyre.

Sudden clutching is also bad for tyres, and many drivers pay little attention to the art of gradually letting in the clutch. The abuse of the brakes also tells on the tyres. Brakes should be used only in emergency, or on very great declivities, or in pulling up at a particular spot. The only excuse for the application of brakes suddenly when at considerable speed is in case of averting an accident. With present-day throttling carburettors the speed of the car is, under the care of a good driver, entirely under his control.

Clutches are sometimes fierce and start off the car with a jerk, but by practice any driver can learn how to let the clutch in easily and smoothly, and so save the tyres from a sudden and great stress.

Again, tyres are often overloaded—that is, the makers of the car and the tyres never contemplated the load sometimes piled on. It is therefore necessary either to restrict the load or to have tyres with a larger weight carrying capacity.

ENGINES AND THEIR ACCESSORY TROUBLES

Their Care and Repair

Nearly all breakdowns or stoppages of motor cars are due to failures such as defective ignition, carburation, or loss of compression. The last is due to leaky pistons, fittings of valves and their seatings, leaky joints, etc.

We will deal first with faulty petrol supply and carburation, and then with defective ignitions due to defects in parts of the systems in use and defective compression, finally dealing with the engine itself and its failings.

The detection or locating of failures or faults is an important subject both for owner and chauffeur, and suggestions as to repairs and remedies are valuable; how far these can be applied on a journey, and by the chauffeur, driver, or owner will depend upon their manual dexterity and mechanical skill. Nowadays, with spare wheels and rims, and carrying spares for all the parts known to be most liable to failure, little knowledge of repairing is necessary by the driver or owner, but both should, if possible, be well drilled in removing faulty parts and fixing in spare parts in their place. It is a good plan for the owner and his driver to become familiar with the spare parts by taking some time convenient and trying all the spare parts into their respective places, removing them and again fixing in the old parts if these are still good.

Petrol Supply Troubles

Sometimes troubles arise on the road through some apparently trifling defect in the petrol supply to the carburettor.

In hill climbing the petrol sometimes falls short, due to the inclination of the car bringing the petrol level too low in a gravity feed, and from the inclination of the car sometimes a float sticks up against its chamber and guides and so cuts off the petrol, or the uptilt of the car may raise the jet level too much above the float feed level. These are points worth remembering.

Pressure fed carburettors are not so much liable to these troubles, and if a hand pump is placed within reach the pressure on the feed can always be raised sufficiently to ensure feed under any running circumstances.

The best system is that shown in Vol. II., page 83, Fig. 98, where a supplementary tank is on the dashboard. This gives us security in all cases that a good head of petrol is available.

A well-made carburettor float should work at all ordinary inclines without sticking up. This sticking up is due to bad workmanship, or a float too small. A small light weight float will hang up more readily than a large heavier float. Some carburettors are fitted with floats which are too small for good hill-climbing.

Water in the petrol often is the cause of misfiring. It is difficult to detect it, and where it is suspected a good plan is to empty the tank completely of all fluid and then fill up with fuel known to be fresh and pure. The dashboard tank is not so likely to suffer from water as the main tank.

With an exhaust pressure fed supply, the pressure may fall while the car is at rest for a time. A small hand pump will of course restore pressure enough to start with, but should the pump not be in order the pressure may be obtained by plugging the exhaust pipe from the silencer, either by a wooden plug or merely by pressing a hand against it. If the engine is then cranked round by the starting handle, enough pressure will be generated in the exhaust to quickly fill the dashboard tank.

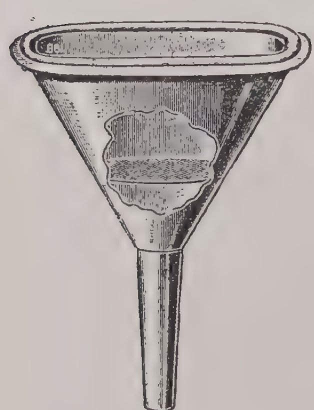
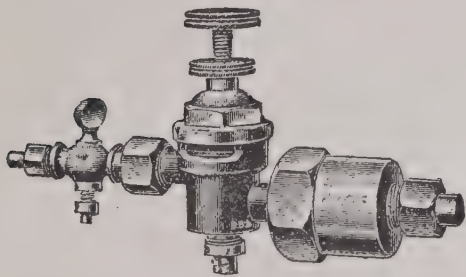


Fig. 125.
Petrol Funnel and Filter.

Another source of stoppages on the road is dirt in the petrol, choking the fine nozzles or passages. This, of course, can be avoided by proper filtering the petrol as it is poured into the tank. A filtering filling funnel is best for this purpose, as shown in Fig. 125. The filtering wire gauze disc is fixed well up in the funnel so as to obtain sufficient area of perforations to allow the petrol to flow through quickly.

Sometimes in exhaust pressure supply systems the filter is built up in one with the double acting pressure regulating valve.

This valve is shown in Fig. 126 complete with the water separator and filter, and in section Fig. 127 in which A is exhaust pipe connection, B the filter of gauze, C pressure valve non-return, and H the regulator valve by which the pressure is kept nearly constant, any excess being



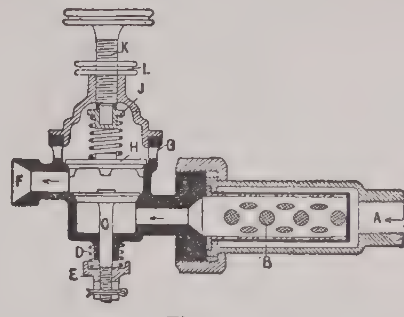


Fig. 126. Pressure Regulating Valve and Filter. Fig. 127.

reduced by blowing through H, which is adjusted by screw K and spring J.

Many funnels have far too small a filter, and the consequence is that it takes a long time to fill up and that with splashing and mess.

Filters may be had of very fine gauze constructed so that they take all the water as well as dirt out of the petrol. Such a filter is shown in Fig. 128; the gauze is very fine, but has a large area, being vertical.

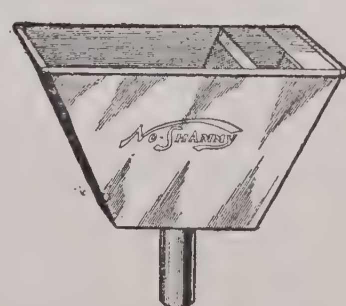


Fig. 128.—Large Petrol Filter.

Petrol which is suspected of containing water should be filtered through this filter into clean tanks or clean petrol tins. Brass gauze, 200 mesh of very fine wire, will not allow water to pass.

A very good filler, dispensing with the funnel, consists of a flexible tube fitting on to any ordinary petrol tin, Fig. 129. It has a dirt filter and an air inlet tube. Every drop of motor spirit goes through the finest separating wire gauze, thus preventing foreign matter or water getting into the carburettor. It has a movable gauge and rest, so that the tanks can be filled in the dark as well as in the light, and it is impossible to overfill, therefore lessening the danger of fire, etc.

It will empty and filter a two-gallon can in about thirty seconds.

Besides filtering petrol in filling up tanks it is advisable to have a filter in the supply pipe between the carburettor and the tank, with pressure feeds, especially exhaust pressure; water and dirt may possibly come in through the feed pressure pipes.

One such filter is shown in section Fig. 130, and in Fig. 131 complete

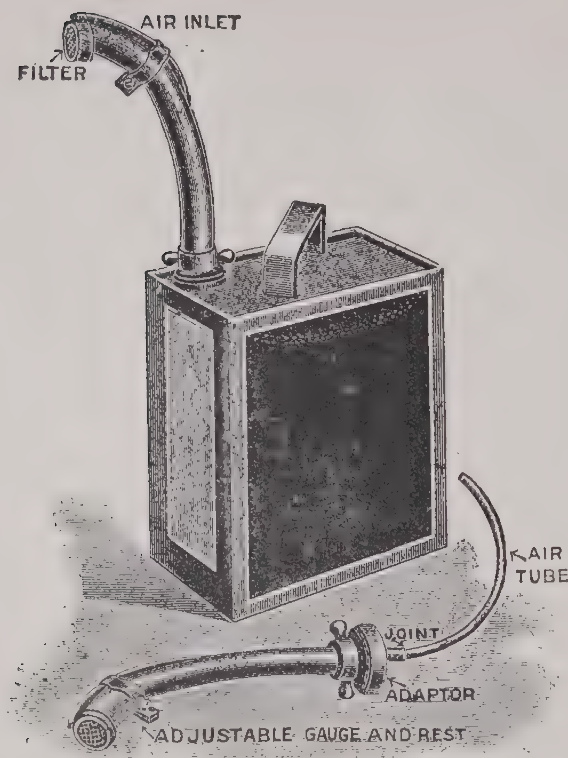
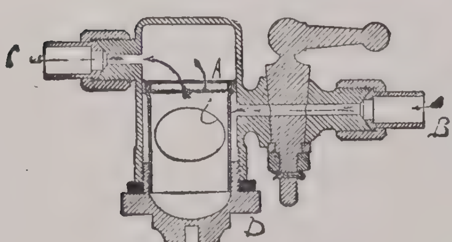


Fig. 129.—Pipe Filter.

with a drain cock. The oil enters at B and is filtered at A, water and dirt falling to the bottom D, from which it can be drawn.

Another filter is fixed to the pipe entering the petrol tank shown in Fig. 132. It gives complete security against any choking in the petrol system. It keeps the carburettor and pipes clean, and it keeps itself clean because it is constantly washed by the motion of the petrol in the tank. It is a simple little fitting, consisting of a slotted tube screwed into the bush of the petrol tank union, the spirit passing into the tube through the fine copper gauze which covers the slots.

Many filtering devices are to be found. Their importance is not exaggerated, for nothing is more aggravating than a road stoppage due to a drop of water or a speck of dirt. Gauze for filters should have a mesh of not less than 120.



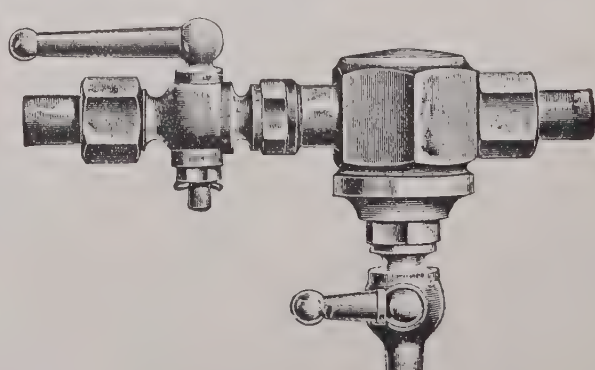


Fig. 130. Supply Pipe Filter. Fig. 131.

Petrol pipe breakage causes road stoppages, generally due to the pipe not being properly supported in its lengths. All breakages are due to vibration of the pipe and they generally occur at unions or junctions.

A man handy with a soft soldering torch or blowpipe can speedily repair any broken petrol pipes or unions good enough to last for a day or two, and rubber solutioned tape may often be used to stop a leak temporarily.

Tape of this kind and also a soldering outfit should be carried. The

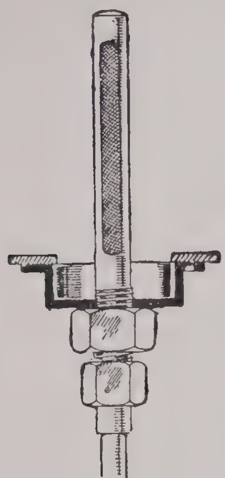


Fig. 132.—Tank Filter.

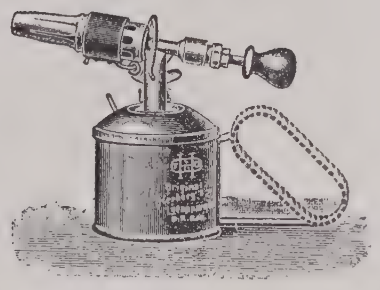


Fig. 133.—Blow Lamp.

tape is used largely by electrical light fitters for insulation. The blow lamp for soldering is shown in Fig. 133. This, with a stick of solder and a tin of "Fluxite," is a useful tool for small pipe repairs on the road.

Carburettor Repairs and Care

The carburettor is sometimes the faulty member to which a stoppage is due, principally, however, due to want of the filtering just referred to causing a choked jet. Prevention is better than cure; with proper filtering a choked jet is very rare. When it does occur, clearing out is not difficult, but a partial choke is not so easily found or cured. Floating particles sometimes cause a lot of trouble. At starting up the engine goes off all right, then is seized with a fit of coughing, chokes, and stops. The floating particles have been sucked into the jet, not firmly, but loosely; when the engine stops, the suction which held them in place ceases and they fall away.

We start up again easily enough, only to stop in the same way. Such cases point to the jet being choked by loose particles.

For a partial choke, racing the engine with the clutch out will generally clear the obstruction.

If the carburettor has an extra air valve it will greatly increase the suction on the jet if the air valve is suddenly closed when the engine is racing, and this sudden increase in suction will usually pull the

obstruction away. But it is generally advisable to take out the jet and clear it by a needle or fine wire.

Carburettors sometimes freeze in cold weather—that is, in cases where the carburettor has a water jacket. The water in the carburettor jacket may freeze if not drained out before a frost sets in, and the car exposed to cold. This has before now occurred, and the jacket or some weak part burst. The drain tap should be opened in the hot water supply and all water drained from the jacket when a car is laid up in winter.

It is necessary to warm the carburettor or the air supply to the carburettor in some way. The evaporation of the petrol absorbs a considerable amount of heat, and if this is not supplied the evaporation is imperfect and loss of petrol occurs; it is carried into the cylinders in the liquid state when too cold.

In many carburettors the exhaust is connected to the jacket for heating purposes. The hot water from the cylinder jackets is circulated through the carburettor jackets in others. The best system of all is to heat the air supply. A small rise in temperature of the air is sufficient.

A box or muff around the exhaust pipe is the best air heater. It should be large and connected to the carburettor by large pipes, so that there is no resistance to the flow of the air.

It is a good plan to feel the induction pipes from the carburettor to the cylinders when any misfiring and irregularity occurs. If they are ice cold it may be surmised that there is something wrong with the arrangement for heating the carburettor or the air it is taking. Sometimes the pipes may be seen covered with dew, or ice, in cases where the heating has failed.

Every carburettor maker claims the very highest efficiency for his carburettor, but we find on inquiring into the efficiency of carburettors that no reliable scientific tests have ever been made in a manner to authoritatively give the real efficiencies.

Such a test is, of course, very expensive to conduct, even if carburettor makers would unreservedly place the carburettors for such rigorous tests.

Fuel so expensive as petrol demands the highest economy, so that it pays an owner to procure the best carburettor possible, and see that it is properly supplied with warm air.

Management of Carburettors

The following remarks are from a reprint from an *Autocar* article on White & Poppe carburettors. They apply equally well to all carburettors, although the White & Poppe instrument is in a class by itself.

"Good acceleration, maximum speed, and high economy, together with slow running, have not yet been obtained in a single carburettor, no matter of what make. The best adjustment for most carburettors is a compromise, but if special qualities in any one of these respects be required

the makers should be consulted, and they will as a rule alter the carburettor to give the desired result. Most carburettors are adjusted to give slow running, very good economy, with average acceleration and power qualities. If the last two are to be considerably improved, the economy is generally effected and a fresh adjustment of the carburettor is required. Power cannot be obtained without petrol. As petrol economy is assumed by most motorists to be one of the most important features, naturally the makers of these and other carburettors study this point in preference to supplying a carburettor with such an adjustment that maximum power is given irrespective of economy in fuel.

If the desired results have not been obtained from the carburettor, and if the adjustments provided do not enable these results to be obtained, the makers should be consulted. Furthermore, from time to time they effect improvements which can often be embodied in carburettors of the older type to bring these up to date. Particularly is this the case with regard to the acceleration qualities of the carburettor. Many cars in use would be improved by a new carburettor replacing the old one, carburettors being still in a developing stage.

Difficulty in Starting

Two of the chief features of the White & Poppe carburettor are the ease with which the engine can be started and the fact that it does not race immediately. To start up the engine with this carburettor, the throttle requires to be opened only the smallest degree. If opened wide, the engine will not start, as the speed of the air through the carburettor is not great enough (i.e. the reduction below atmospheric pressure within the carburettor is not sufficient) to cause the petrol to be drawn out of the jet and broken up. As with many carburettors it is necessary to open the throttle wide to start the engine, ignorance of this feature of carburettors often causes delay in getting the engine under way.

The carburettor should not on any account be flooded at starting, and to prevent this being done the needle valve stem is enclosed at the top. If the carburettor should flood owing to the needle requiring to be reground or to the presence of grit, difficulty will be experienced, the mixture drawn into the engine being too rich. The procedure in such a case is to turn off the petrol and start with the throttle opened wide. When the engine has been started in this way, the throttle should be shut down slowly and the petrol turned on again. The cause of the flooding should then be ascertained and remedied. If this treatment be not effective, the lid of the float chamber should be removed and the float withdrawn, and the petrol in the float chamber soaked up with a piece of cotton-wool or rag. When soaking up the petrol in this manner,

care should be taken to remove all particles of grit, etc., in the float chamber.

The needle valves of these carburettors very rarely require re-grinding, but a very simple form of adjustment is provided on the needle valve stem, which may require alteration after grinding in, to restore the previous petrol level.

Erratic Running

If the carburettor has been in use a considerable time the engine may be found to run badly at low speeds and the exhaust to smell rather strong. This is due to the mixture being excessively rich, and in such cases, owing to the fact that the conical surfaces at the top of the jet have become scored by the presence of grit at this point. The result is that too much petrol is allowed to issue from the jet, and this can be remedied by refacing and grinding in these parts.

Occasionally the throttle barrel may stick, and as with most cars it is returned to the closed position by means of a spring, the throttle is liable to remain slightly open and cause the engine to run faster than is desired.

If the throttle stick wide open, the trouble may be due either to the closing spring being defective or not strong enough, or to the throttle barrel freezing, the latter particularly applying in cold weather.

Carburettors require a considerable amount of heat to ensure their best operation, for otherwise the moisture in the air condenses on the walls of the throttle and freezes. The usual method is to heat the air intake. The makers supply both hot water and exhaust gas heaters as required, but the heated air method is the best provided the air intake pipe is short and of very large diameter.

The throttle surfaces should be smooth, but in course of time the presence of dust may score these surfaces; this can be remedied by polishing the surfaces with some brass polishing mixture.

The power obtainable from any carburettor can largely be varied by the amount of heat imparted to the carburettor. The liquid petrol has to be converted into a gas in order to be combustible, and this can either be done by pulverisation, in which case the liquid is broken up into a very fine spray consisting of minute bubbles of relatively large surface, with the result that surface evaporation occurs, or heat can be added and the liquid vaporised or gasified. In any carburettor, having one comparatively large jet, outlet pulverisation alone cannot be responsible for gasifying all the petrol, and with the air at 60° Fahr. insufficient heat is present to vaporise the petrol from the jet, so that the air entering the carburettor must be heated, or part of the petrol will not be fired. This is the cause of weakness of acceleration and slight smell when starting up from the cold on a cold morning. Most carburettors are fitted with a hot air intake pipe. In

the summer this can sometimes be dispensed with, and a considerable increase in power at high engine speed is the result. The only drawback in such cases is that the engine will not run very slowly, and acceleration will not be good for the first three or four minutes the car is on the road.

The Fitting of a Carburettor

Many a carburettor is prevented from displaying its good features by being fitted up incorrectly. The mistake most frequently made is the fitting of a warm air pipe that is too small in internal diameter. A little consideration will show that such a pipe, by restricting the air supply, will promote an increased suction of petrol from the jet. It is a simple matter to have the correct size of pipe fitted in the first place,

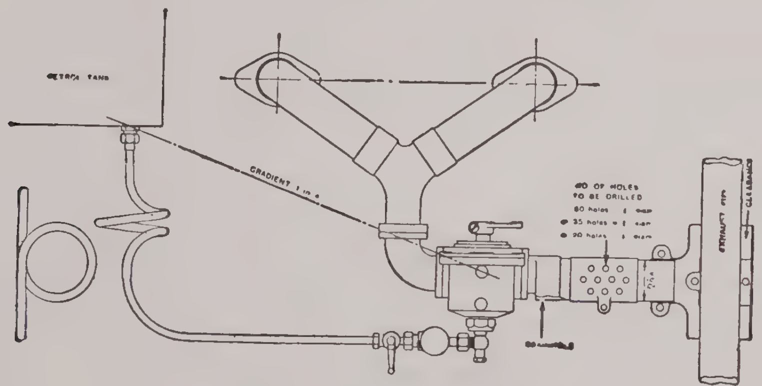


Fig. 134.—Carburettor Fitting.

and it will then be found that the carburettor, working under suitable conditions, will give smooth running, full power, economical consumption, no overheating, and a clean exhaust. The diagram (Fig. 134) shows the most suitable way of fitting up the carburettor.

The observations of the De Dion instructors on the subject of defective carburation may be of some value as given below.

If the engine will not start, despite the fact that the ignition system is proven to be quite in order, the "gas," or mixture of petrol vapour and air, cannot be properly proportioned.

Lift the carburettor needle, or float spindle, and if the carburettor does not "flood," ascertain—

(*a*) That there is petrol in the tank;
(*b*) That the petrol tap is turned on;
(*c*) That the air hole in the petrol tank filler cap has not become obstructed; and
(*d*) That the gauze filter of the carburettor is in order.

To do the latter, close the petrol tap and unscrew the waste cock under carburettor. Clean the gauze, and, before replacing it, momentarily open the petrol tap. If the petrol does not flow freely it may be concluded that the pipe is choked.

Close the petrol tap, take down the piping and clean it out, either by pushing a wire through it or by blowing through it with the tyre pump.

If petrol flows freely, the gauze is in good condition, and yet petrol does not come out through the spray, the carburettor itself needs taking apart and cleaning.

If the trouble is due to insufficient petrol, probably the misfiring will cause loud explosions in the exhaust box. It is then necessary to proceed in just the same manner as when there is no petrol at all, but first make sure that the needle in the float feed is properly adjusted, because the trouble may easily be cured by adjustment of the needle valve.

Excess of petrol is shown by a black and malodorous smoke at the exhaust outlet. This may be caused through the needle requiring adjustment, but there are less evident causes, such as—

A bent or jammed needle;
Bent rockers; or
A punctured float

All these faults may have been caused by rough treatment of the carburettor. If it is not possible to straighten the needle, or put the rockers into proper shape, they must be replaced by new ones.

If the float is punctured, it will be weighted down by the petrol which will have got inside, and this will have upset its buoyancy. The petrol can be heard inside the float, on shaking it near to the ear.

First the hole must be found. As this is generally microscopic, the best way of finding it is to immerse the float in warm water, when bubbles will rise from the hole.

To get the petrol out of the float, it is frequently necessary to increase the size of the first hole and make a second hole in the float, When this has been done the two holes should be closed by solder, or, temporarily, by two pieces of clean match stick.

As it is essential that the float should be of the correct weight, and as it is difficult to repair one properly, a spare float should be carried on the car. The punctured float may be sent for repair at any other time.

It is held by many that a jet in a carburettor which perfectly pulverises the petrol to form a perfectly fine spray saves petrol or gives more power for the petrol consumed. It is probably quite true for heavier fuels, but doubtful for the finer petrol of low sp. gr. The finer the spray the more easily is the mixture fired, and the more rapid the combustion; hence, greater pressure produced. Heavier oils must of necessity be atomised thoroughly in order to make them ignite. But the finer petrol

should gasify in the air in the carburettor, and to ensure rapid and thorough gasification the air should be warmed before entering the carburettor.

No pulverising or atomising device can break up any liquid into particles so fine as those of a gas, not by a thousand times or more. All the same, it assists quick gasification to atomise the liquid as finely as possible as it issues into the air with which it is to mix as a gas.

A jet atomiser is shown in Fig. 135, the petrol passing from the jet into a chamber specially constructed to break it up into the finest spray as it issues into the air. Many such devices have been brought out, but just how much petrol they save is not properly ascertained. The motor car engineer's tests do not extend beyond road tests to find how many miles the car goes with, and how many without, the device under test. Such tests are rough and ready, but altogether unreliable. Any tests of fuel consumption per brake horse-power must be made on the test bench where the necessary accuracy and careful observations can be made with fuel. Road tests of fuels, carburettors, silencers, atomisers, and suchlike are worthless.

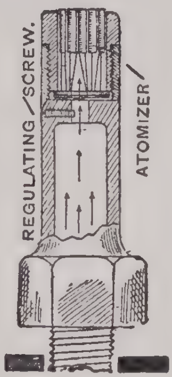


Fig. 135.
Atomiser.

An atomiser which can be readily fitted over any jet is shown in Fig. 136. It consists of a spiral of fine brass wire closely wound, and conical at the upper end. The mandrel hole in this end must be stopped by a blob of solder. It is fitted on to jet with a left hand twist, taking care to leave only the cone part above the jet and low enough to miss roof of mixing chamber. The petrol impinging against the inside of the cone will be broken up and drawn through the coils into the chamber. Leave the parallel coils slightly open, so that any surplus petrol will be retained and drawn off into gas instead of dripping down the jet. If so fitted considerable advantages are claimed in quicker vaporisation, resulting in easier starting, increased power, slow running, and economy of petrol. It is known as Terry's spiral vaporiser.

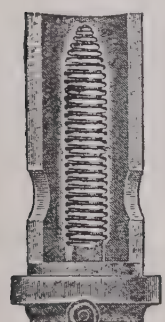


Fig. 136.
Atomiser.

The Mills petrol economiser is shown in Fig. 137. This can be fitted to most carburettors by the owner, and in some cases will give considerable improvement. It is shown in section, Fig. 137, made in any length and diameter to suit the particular carburettor.

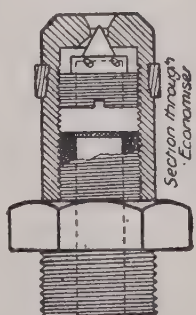


Fig. 137.
Economiser

Apart from choking by dirt, carburettors do not fail often. Sometimes a failure may occur through the float leaking very slowly at some small hole.

Temporary remedy is to varnish it all over with a thin coat of fine glue; this will stop any invisible crack or hole. A more permanent cure is to have it nickel plated. Larger openings can be seen by examination with a magnifying glass and these can be soft soldered. Leaky induction pipes allow more air to enter in unknown quantity and cause weak mixture.

Ignition Faults and Repairs

Most of the road failures are due to the petrol supply troubles and ignition troubles. In case of failure it is safe to inspect these systems first; if it is then found that the mixture is right and the ignition right, we must proceed to examine the engine for the fault. Before entering upon the discussion of engine faults we will consider the ignition system and its faults.

The universal system of ignition is now by magneto; a system so perfect that few faults arise, except those provided for or against. The magnets lose power and require remagnetising. The make and break points become worn and require smoothing over.

Insulation may fail in the magneto, in which case only experts can deal with it. Insulation may fail in the wiring and plugs; these can be dealt with by an intelligent chauffeur.

In many cases a dual system is fitted—that is, a magneto and accumulator system combined. The accumulator is used for easy starting and also in case of magneto failure. The dual system has much to recommend it and is largely in use. The only fault it has in practice is that it may fail when least expected from the exhaustion of the accumulator. No reliable indicator has ever been made to show that an accumulator is nearly discharged, nor is there any indicator to show that it has been fully charged, and this uncertainty leads to troubles.

By far the best system of ignition is that in which a dynamo and accumulator are used for ignition and lighting the car, and, if possible, also for starting. In this system the accumulator is always fully charged, and might be run down only in case of a break down of the dynamo which could not be repaired in less than two or three days, during which time the accumulator alone can be used.

Besides the use of accumulators for the dual ignition, they are still used on some cars for ignition alone, and are, of course, indispensable on cars with electric lighting or electric starting systems.

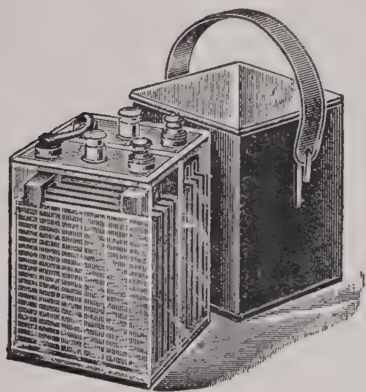
Like everything else produced by man, they are liable to troubles and require a reasonable amount of care and attention. On the whole, they behave satisfactorily, and are to be relied upon as much as any other component of the ignition system.

Not so long ago only the lead accumulator was available with its acid electrolyte. Now we have also the Edison steel accumulator with alkaline electrolyte, and it seems to offer a better battery for ignition and other purposes.

Accumulator Faults

The ordinary lead acid cell suffers most from the disintegration of the plates, mechanical vibration, from too rapid discharge, and from discharging it below a certain amount of voltage.

Some types are more robust than others and stand more rough work. In the lead cells the plates are formed of an alloy of lead and antimony in the shape of cellular grids. Into the cellular grid is compressed a



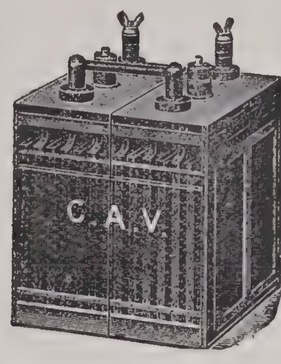


Fig. 138. Lead Accumulator. Fig. 139.

paste of lead oxides, and cells are made up of 3, 5, 7, or 9 plates interleaved as shown in Figs. 138 and 139.

If at any time the battery is run down too low, the paste swells and becomes loose, falling out, and this swelling also twists or buckles the plates, and several repetitions of overdischarging ruins the plates entirely. It is better to have transparent cells of celluloid than ebonite cells, in order to see inside and examine the condition of the plates. If small pellets of the paste should get in between the plates so as to join them together, the electricity will flow across these pellets and discharge the battery. To prevent this, separators are used, generally perforated corrugated celluloid sheets placed between the plates; they may be seen in Fig. 139. In some makes glass wool is filled in between, in others spun and woven glass sheet is used as separators.

Celluloid cells should be protected by a box into which they fit well, as shown, Fig. 138, so that they do not shift about, and the terminals should be protected from corrosion by proper protectors.

The first rule of care for lead accumulators is to keep them always well charged. The second, never charge them too rapidly. Every accumulator should be marked clearly with the number of amperes maximum it will take while charging, and the ampere hours at the maximum rate.

It should also be marked with the number of amperes maximum discharge rate, also number of ampere hours it will give at maximum discharge rate.

Now, to prevent over discharging, nothing is simpler than to fix an ammeter on the dashboard with a button, by pressing which the ammeter may be put in circuit for a few seconds to show the condition of the cells.

The ammeter must be made for the cells it is to be used with, so as to carry the proper current. A cell with a good charge will give the full current up to twice its maximum discharge rate. Say the battery is one of 4 volts to give 2 amperes; in that case the total normal electrical resistance of the circuit must be 2 ohms including battery, induction coils, and wire connections when working. If now we put in an ammeter in place of the coils, by means of a press button so adjusted that the total resistance is now 1 ohm, the current should be doubled, or nearly doubled, if the battery is fully charged; but if the battery is run down the current, after the first jump up, will gradually fall away. The current should be cut off when the fall has become decided and the battery sent to be charged.

Another way to test an accumulator to find whether it is run down or not is to couple a voltmeter across its terminals and short circuit the battery by a known resistance, such that a current of about twice the normal current would flow if the battery were fully charged. If it is run down the current will flow strong for an instant and gradually fall. This is due to fall in voltage, and the voltmeter will show nearly 2 volts per cell for an instant and then gradually fall. The circuit should be opened and the test ended when the volts fall to about 1·5 or 1·6, showing the battery is run down.

The running down of the battery will be shown of course very soon on the engine ignition, for it will begin to misfire. The misfiring may of course be due to other causes, but it may be taken as rising from the run-down battery if after a short rest the engine is started and for a short period fires all right and begins to misfire again. This behaviour is due to the fact that a run-down battery will recover somewhat during a rest, but soon becomes again exhausted.

A densimeter or hydrometer gives an indication of the state of the charge in a battery.

The sp. gr. of the acid solution should be 1·185 when run down so far that it should be recharged. When fully charged the gravity will rise to 1·2 and 1·25 sometimes.

It would be worth while using specific gravity beads in cells used on cars for such important purposes as lighting and ignition. A white bead to float when fully discharged, and sink when half discharged, and a red bead to sink when fully run down. In many cells there is ample room for indicating beads and to show the owner or chauffeur the condition of the cells.

A handy testing voltmeter is shown in Fig. 140, and one which can be used also for ampere tests is shown in Fig. 140A with two scales.

Dry batteries may be used for ignition. It is important in using

dry batteries to have a coil suitable for their voltage and current, and also that two sets or batteries be used, for the purpose of alternately resting one set and working the other, for the dry battery when run down is not by any means exhausted. Should it show signs of running

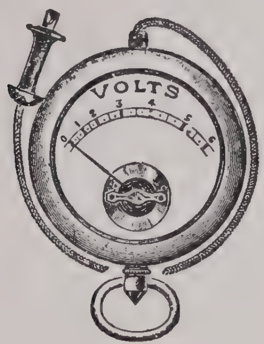


Fig. 140. Volt and Ampere Testers. Fig. 140A.

down at the end of, say, four hours, it will recover in a three hours' rest and run for another three hours, so that to get the best out of dry batteries the twin battery system is necessary. A time switch may easily be set up which automatically switches over from one battery to the other every two or three hours. A battery of dry cells is shown in Fig. 141.

Owners and chauffeurs should always purchase accumulators filled up and fully charged. Many makers send them out dry and only half formed. They then require filling up with acid solution 1·171 to 1·175 sp. gr., and charging for a long period, all of which is best done by experts, as the first charge, if not thoroughly carried through, will leave the cells weak and unsatisfying. Of course, an owner or chauffeur who may have specially studied accumulators and become expert in their charging, forming, and care, can fill up a new cell with a solution of acid in pure water, and give it its first forming charge, with an ammeter and voltmeter in circuit, and carefully watch the operation throughout, following the maker's instructions; but unless confident of doing it well, it is best to have the cell delivered charged and filled.

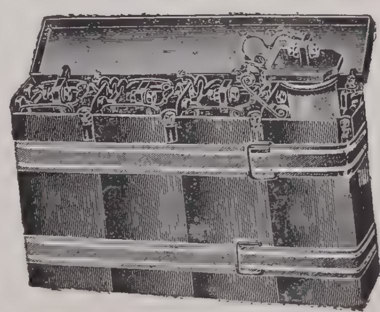


Fig. 141.—Ignition Dry Battery.

Lead accumulators should last from five to seven years if never allowed to run down below a certain voltage at the maximum current, and always fully charged when charging.

Cells in celluloid bought ready formed, charged, and filled are not likely to develop "frothing" when being charged; if they do they should be

emptied and washed out with warm water, preferably clean rain water, several times, then refilled with acid solution and submitted to a long charge, at less than maximum rate.

Cells which are kept as spare cells should be dealt with as follows:

An accumulator which has never been charged may be safely stored if it be wrapped up and kept in a dark, dry place. One which has been charged, and which it is desired to store without use for an indefinite period, should be coupled up to a lamp of the same voltage as the complete accumulator and discharged until each cell registers 1·9 volt. The acid should then be drained off to the last drop, and the accumulator stored as with a new and uncharged one mentioned above. The slight white coating on the plates which may be formed when the cell is drying need not be the cause of worry, for it will disappear at the first charge. If a charged accumulator is to be put by for any period up to six months, it should be charged to its utmost capacity, the terminals should be wiped perfectly dry and greased and covered by a protector.

All these foregoing instructions refer only to lead plates in acid. The case is very different with steel alkaline Edison plates. The life of a lead battery depends upon the care it receives. The steel battery requires no such great care and has a longer life. It is claimed that at its rated capacity it will give 1,000 charges and discharges without any indication of failing.

One feature that has hindered the full application of the lead battery is its excessive weight; lead battery plates have to be made heavy to stand the vibration received in vehicle operation.

An Edison storage battery has nearly double the capacity of a lead battery of the same weight, and it can be left for an indefinite period in either a charged or discharged condition without deterioration. This is of inestimable value.

The care necessary to obtain the very best results is of a very simple nature—namely, the occasional filling of the cells with pure distilled water.

The most important factor in storage battery operation, however, is the successful operation over a period of years with a minimum of expense. A lead battery with care will possibly give a total of 300 complete discharges, at the end of which time the capacity will have decreased to such an extent as to make further operation unreliable.

The battery may be charged at a very high rate without damage. It is best to give it a tapering charge—that is, to begin at a high rate, say double the normal rate, and gradually taper off as the temperature of the cell rises.

The cell is not injured by frequent charging. It is not necessary to discharge to a fixed minimum before recharging in order to get good results, as in the case of lead. The lead battery people are very particular on this point, and their printed instructions are very explicit. The battery may be charged as frequently as deemed

advisable to keep it fully charged. Such treatment is good for it rather than harmful, although it is simply a matter of keeping the cells supplied with current which may be utilised when needed. A continued charge—overcharge—does nothing more than evaporate the water contained in the electrolyte and waste current; it does not injure the plates.

The cell may be discharged in any manner suited to the service, low or high, from a fraction of an ampere to a short circuit, and no harm results. There is no minimum voltage at which discharge must be discontinued for fear of ruining the battery. The cell may be discharged to zero voltage and left standing indefinitely and no harm will result. All that is needed is to charge up and go ahead.

There is no such thing as sulphation in the action of the cell, and its disastrous effects (to lead batteries) need not be considered. This is the plague of the lead battery, the enemy that saps out its life.

The electrolyte of the cell being a solution of potash and not an acid, the steel plates are preserved rather than destroyed. Theoretically iron or steel immersed in a potash solution will last for ever. There can be, therefore, no corrosion of the plate, container, or terminals.

The maintenance or care of the battery is purely a mechanical operation. It is not necessary to get into the cell for any purpose; in fact, it is not possible to do so.

There are two important essentials—to keep the plates covered with solution, by adding pure water as needed, and to keep the steel containers dry and clean.

The amount of water used depends entirely upon the service and the care that is taken in charging not to waste water by overcharging unnecessarily. The saving of water at the same time means the saving of current, which in turn means money saved. It is not necessary to give the cell long overcharges in order to remove sulphate as in the case of the lead cell.

Fig. 142.—Edison Ignition Battery.

Once in about two hundred and fifty complete discharges it becomes necessary to renew the solution, for after so much work it shows a loss in strength resulting in a loss to the battery of about 5 per cent. in its capacity. The renewal of solution not only restores the 5 per cent. decrease, but carries the capacity several per cent. higher than it was before. This is one of the characteristics of the Edison cell, its continued growth in capacity. Distilled water and the prepared solution are inexpensive; consequently the cost of maintaining the Edison battery, considering the service obtained, is nominal.

The following table will give an adequate idea of the dimensions, capacity, and weights of the Edison ignition cells made up into batteries giving 6½ volts on open circuit (see Fig. 142).

"B" TYPE IGNITION SETS

Type	No. of cells	Volts	Ampere hour capac.	Weight in tray. lb.	Overall dimensions in inches					
					Cells in tray			Steel box		
					Height	Width	Length	Height	Width	Length
B-2. .	5	6½	40	27¾	9⅝	6⅜	11$\frac{5}{16}$	10¼	7¼	11¾
B-4. .	5	6½	80	43½	9⅝	6⅜	16¾	10¼	7¼	17¼

Defective Magneto Ignition

When an engine refuses to start or has stopped, and the petrol or fuel supply has been found all in order, the next thing to do is to examine the ignition system.

First of all examine the plugs. To do this, unscrew each of the plugs from the cylinders, and, with the wire attached, rest the body of the plug on the engine. If the ignition is in good order, bright sparks will be seen between the centre and body of the plug, when the engine is revolved by the starting handle. When making this test, the terminal caps or screws of the plugs must not touch any electrical conductor except the wire.

If there are good sparks at all the plugs, the ignition is all right, and the mixture must be at fault.

If there is a poor spark, or no spark, at one plug, take off the wire and hold the end of it about half an inch from the engine, and turn the starting handle. If there are sparks from the wire to the engine, it is the sparking plug which is at fault. It is then only necessary to clean or change the plug.

If there are no sparks between the wire and the engine, take off the magneto cover and examine the distributor of the magneto. See that the carbon brush makes good contact with the contact segments connected to each wire terminal. Sometimes the end of the carbon requires filing, owing to its contact surface becoming too hard.

If the sparks are intermittent, examine the contact breaker. See that it moves freely, and, if necessary, remove the bell crank lever and clean the bearing of it with petrol. If necessary, adjust the contact breaker, and go through the above-mentioned tests again.

If the contact breaker is properly regulated and there are no sparks between the wire and the engine, carefully examine the wires and their connections. Replace any faulty or doubtful wire.

If the wires and their connections are all in good condition, the contact breaker is properly adjusted, and the switch is in order, and still no

spark, then the source of the current must be at fault. Perhaps water splashed on the magneto has set up a short circuit. In that case, there is nothing to be done but to wait till the magneto dries. The magneto must not be removed and placed near a fire. This would ruin the insulation of the armature windings, etc.

A magneto seldom gets seriously out of order; but if one does, it must be sent to the magneto manufacturers. All that it is advisable for the driver to do personally is to clean the ends of, or renew, the carbon brushes and adjust the platinum contacts. Any other work needs expert hands.

Before blaming the magneto, see if the drive of the armature is correct, and, if the driving mechanism is not properly engaged, correct this, and again test the ignition, as explained in the preceding paragraphs.

Sometimes misfiring occurs only in one cylinder. To find which is misfiring, open the compression taps one at a time while the engine is running and note results. When the faulty one is opened it will not reduce speed of engine, but if the firing cylinders are opened the speed at once drops. Or short circuit each plug in succession by a screwdriver or hammerhead with a wooden handle by connecting the terminal with the cylinder. When the faulty one is short circuited it makes no difference in the running, but when a faultless one is shorted it reduces the speed and the difference can be heard in the exhaust sounds.

Then disconnect the wire and remove the sparking plug of the faulty cylinder; reconnect the wire and place the plug upon the cylinder so that the metal portion of the body only is in contact, and turn the starting handle of the car. If no spark, or only a weak spark appears, the fault is probably in the plug. Examine the points, and if not clean, brush with petrol, scrape with a knife or sand paper; then measure the distance between them, which should be ½ mm., or the thickness of a visiting card, and if necessary adjust these accordingly. If after this the spark is unsatisfactory, examine the plug, as a cracked porcelain insulator may be the cause of the trouble, or it is possible in wet weather that a short circuit may be formed through moisture getting on the insulator.

It should be remembered that in consequence of the resistance caused by compression in the cylinders, a stronger current is required to produce a good spark under compression than when the plug is in the open air, so that in testing as above there may appear to be a sufficient spark, but when the plug is replaced in the cylinder the spark may not be strong enough to explode the mixture.

If the plug fails to spark, examine the wires very carefully to see that there is no breakage. If a break be found in a wire, replace it by another, or the old wire may be temporarily repaired by peeling off the insulating material at both broken ends for about half an inch, twisting them into each other, and binding with insulating tape. The sparking plug will indicate if the current is passing effectively.

The figures over the four terminals of the magneto show to which

cylinder each wire is connected, No. 1 being the cylinder nearest the radiator. This is the case in Humber cars, and some others, but it is not always so. If it is necessary to remove the magneto, the teeth on the coupling flange and ring should be previously marked to ensure the same timing when the magneto is replaced.

Before withdrawing the magneto the coupling ring must be slackened by unfastening the screw.

Some minor defects in magnetos which are easily detected may be remedied by simple adjustment. The contact breaker may be stiff owing to the bell crank lever, which has a fibre bush bearing, seizing too tight on its pin, generally due to swelling by damp.

The return spring is not very strong, so that any stiffening of the lever may prevent contact. It is well in case of misfiring to see to this point and try the lever's freedom. Obviously it is easily made free by slightly reamering the bush to widen the hole. No damp or water should ever be allowed to enter the magneto.

The two fibre rollers in some magnetos which actuate the make and break do not wear equally; this causes irregular firing. In such a case the rollers should be replaced by new ones, or carefully made equal by a good turner. The fact is, fibre is not a very reliable material for the purpose, although it is perhaps the best we can get.

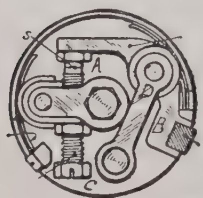


Fig. 143.—Magneto Contact Breaker.

Fig. 143 shows the magneto contact breaker. The platinum contacts are at A, one on an adjustable screw, whereby the length of the break can be adjusted by screw C. The bell crank lever carries the other platinum contact on one arm and an insulated pad B on the other arm. This pad comes into contact with cams on its rotation, which lifts the lever and breaks the contact at A, causing the spark to pass in the cylinder.

The driver or owner should study this part of the magneto. It is the only part he can adjust and it sometimes causes stoppages. The most common fault is found to be the setting of the screw C, so that the break at A is too wide. The break should be not more than the thickness of a piece of stout writing paper, about $\frac{1}{100}$th of an inch is right.

The joint D should be quite free, but without shake; when much worn it should be rebushed with care. The Bosch Company supply a small case fitted with a complete make and break and all the screws and parts required to replace any of the parts which may fail on the road (see Fig. 144).

Sometimes after some hours' running the engine begins to misfire on the magneto, while it will go on all right on the battery for an hour or more, and then when tried on the magneto again, it runs on quite nicely as if the magneto had been refreshed by the rest. In such a case, probably to begin with, the make and break has had the break slightly too wide and the contact platinums have been burned by the long run, so

Fig. 144.—Magneto Spares.

as to make bad contacts. The remedy is, of course, to clean the platinum tips. This is best done by a dead smooth watchmaker's flat file.

The reason why the engine went all right again on the magneto after running for a time on the battery, and that without doing anything to it, was that while running on the battery the platinum points without current passing were all the time hammering each other, and so smoothed down the points, making good contact again.

In any case of the kind the platinums require smoothing and setting closer.

Sparking plugs are liable to some faults. Magneto ignition plugs should have short sparks gaps, much shorter than the gap which works quite well with coil ignition. Where both coil and magneto are used, the gaps should be made of a short width to suit the magneto.

It is of importance that all the plugs should be as near as possible of the same spark gaps in width; for this reason the plugs which have one or both electrodes adjustable are preferable. For example, see Fig. 145. The central pin is one electrode, the crooked pin the other electrode; with a small pair of pliers it is easy to bend the crooked pin more or less to adjust the spark gap. Another adjustable gap is shown in Fig. 146, where one electrode is a ring and the other a bent tapered wire. By bending the taper into the ring an adjustment can be made.

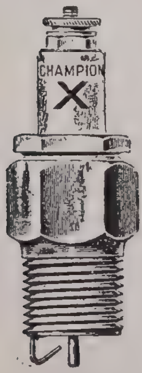


Fig. 145.

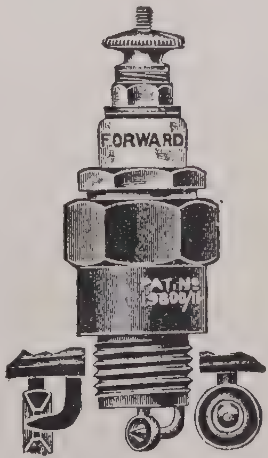


Fig. 146.

Plugs fail generally in the insulation, which allows the electric current to leak, and with wet or dirty plugs the current may leak along the wet or dirty surface of the insulator. A new plug is the best remedy for failure of insulation.

When the insulation fails, it may be tested by a spark gap in the circuit. This spark gap has two electrodes in a glass tube covered with ebonite with a slit on one side; by inserting it in series with the faulty plug, or with any plug whose insulation is to be tested, and

working the coil or magneto, a spark will be seen at the gap terminals in the tube, but no spark at the plug gap when the insulation is bad, but if the insulation is good a spark will appear simultaneously at both gaps.

We have already referred to testing for misfiring, and cutting out one plug after another to find which was the faulty cylinder. A little cut-out for the purpose will be found handy; it is shown in Fig. 147. It consists of a little clip to fix under the plug terminal, and has a bent

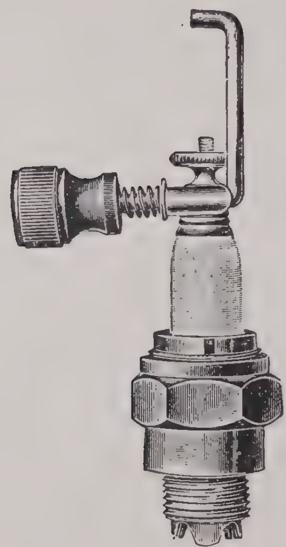


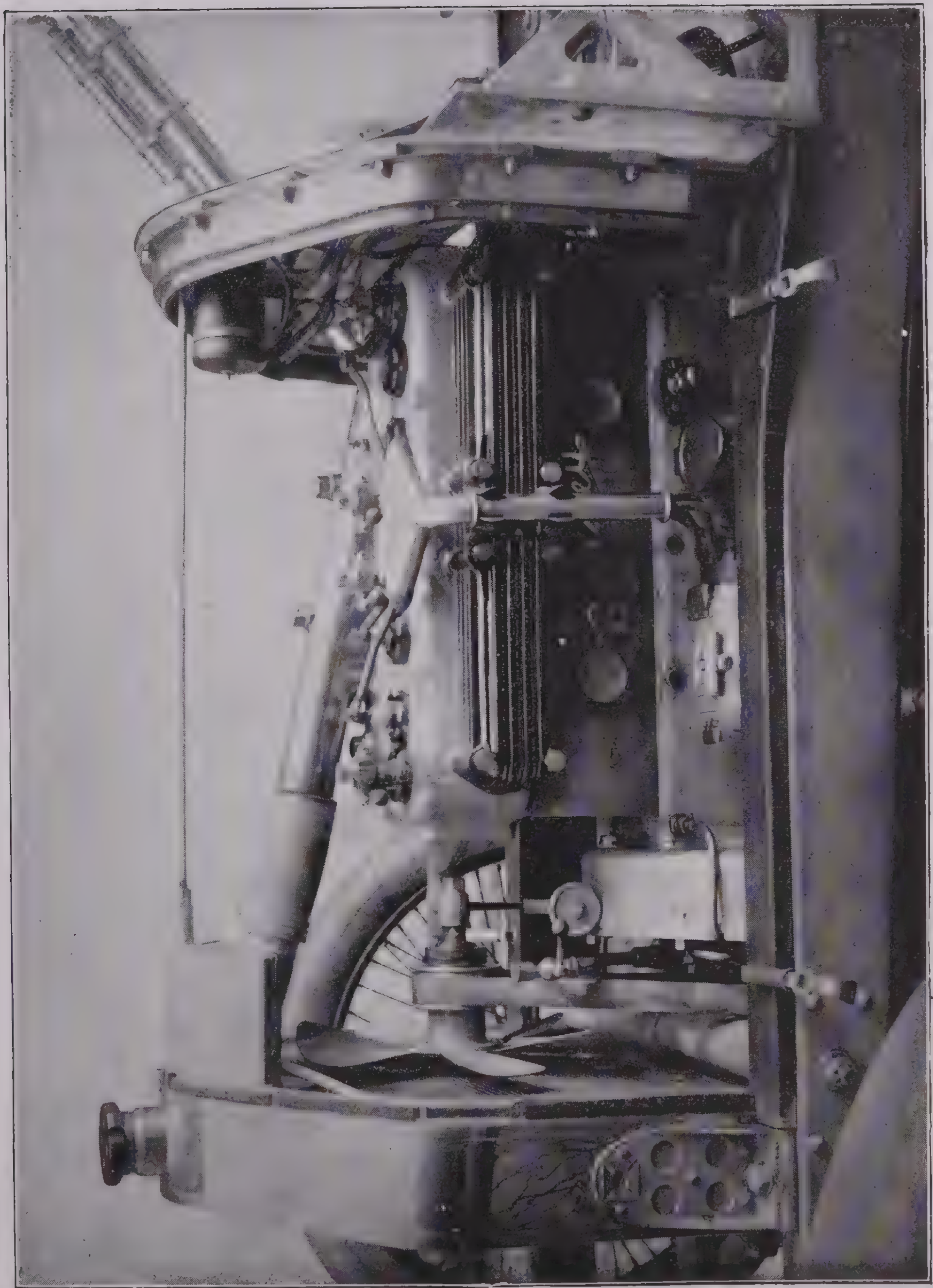
Fig. 147. Plug Testers. Fig. 148.

wire whereby it can be bridged to the earthed part of plug. Another device for the same purpose is shown in Fig. 148. A small lever with an insulating handle is provided for short circuiting; it is held up by springs.

Plugs should be examined every three or four weeks, and all soot or carbon crusts removed carefully and the points or electrodes all adjusted to short equal gaps.

A difficulty in firing occurs in some cases when the spark gap does not extend far enough into the combustion chamber. A longer nose is then required on the plug. It is not safe to merely extend the wires on the end of the plug between which the spark occurs; if these are made long they are apt to become red hot at the ends and cause backfiring at high speeds. On the other hand, some plugs project too far into the combustion space, in which case they become sooted up, especially when much lubricating oil is forced into the cylinders. The remedy for this is to use washers to raise the plug higher in its pocket.

Much has been said and written about having two ignition sparks simultaneously in each cylinder, the two gaps connected in series. No doubt two or three sparks will more rapidly and certainly fire a charge



UNDER THE BONNET OF A CROSSLEY CAR, SHOWING HOW MUCH OF THE POWER UNIT MAY BE ACCESSIBLE FOR REPAIRS.

than one spark, especially in large cylinders, but in small cylinders such as are used on motor cars one well-adjusted good spark is all that can be desired.

Dual ignition can be worked from one set of plugs, as we have already shown in Vol. I.

It is a great convenience to have the two ignitions, magneto and battery. A car can hardly ever be stopped from ignition troubles if it has the two systems, each of them ready for independent work.

Many cars have only magneto ignition. To convert these into a dual system with one set of plugs is not an easy job; it requires to be done at the works. But to fit up a coil and battery ignition with a separate set of plugs is simple. It requires a two-way adapter to fit the two plugs to the one ignition hole as in Fig. 149. This arrangement may bring the ignition points too far from the combustion chamber in some cases.

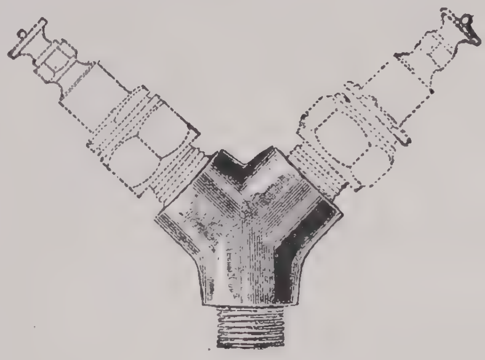


Fig. 149.—Dual Plug.

In sleeve valve engines two plugs are sometimes used, as in Fig. 150. These are necessarily in a deep pocket, and the terminals very close to the sides of the pocket, and this may cause a failure by some loose or stray end of wire making a contact. It is necessary to carefully examine all the connections to these deep-seated plugs.

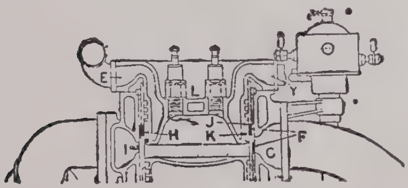


Fig. 150.—Doubled Plugs.

The most of the troubles from which car stoppages may occur on the road have now been referred to in the carburation and ignition systems, and their remedies.

Spare parts are the chief reliance of the driver and owner; these can always be fitted better and cheaper than making patches and repairs on the road. Reference may now be made to the chief details of the magnetos.

In Vol. I., page 182, the Bosch Magneto D3, D4, D6, is described for 3, 4, and 6-cylinder motor cars, and the later type ZR4 on page 193, Vol. I.

The parts requiring replacement in course of time are shown for the ZR4 magnetos in Fig. 151, and the following is a table of the names and numbers of the component parts:

Dust Cover, Carbon Holder, and Parts for Magneto Box

23, Top fastening screw for front end plate.

24, Bottom fastening screw for front end plate.

Fig. 151.—Magneto Spare Parts.

25, Dust cover (zinc).
26, Carbon holder with safety spark gap.
27, Fastening flange for carbon holder with safety spark gap.
28, Plate for safety spark gap.
29, Fastening screw for plate 28.
30, Carbon holder.
31, Conducting tube in carbon holder 30.
32, Carbon brush for carbon holder 30.
33, Carbon brush for conducting tube.

34, Spiral spring for carbon brush 32.
35, Spiral spring for carbon brush 33.
36, Fastening screw for safety spark gap and dust cover 25.
37, Felt washer in flange 27.
38, Spring washer for holding carbon holder 30 in flange 27.
39, Dust cap with oil cover and felt packing.
41, Fastening screw for dust cap 39.
63, Oil cover on rear end plate.
64, Fastening pin for oil cover 63.
65, Oil cover on dust cap 39 for right hand magnetos.
66, Oil cover on dust cap 39 for left hand magnetos.
67, Fastening screw for oil covers 65 and 66.
68, Spiral spring for oil covers 63, 65, and 66.
81, Screw with frame carbon and spiral spring.
82, Frame carbon.
83, Spiral spring for frame carbon 82.

The parts illustrated in Fig. 152 are those which are more likely to be required than the foregoing parts. They are the vital parts in the control and proper working of the ignition system, and in adjusting the timing of the spark, its advance and retardation.

Contact Breaker and Segment Box Fig. 152

96, Segment box for magnetos with fixed ignition.
97, Segment box for magnetos with variable ignition.
98, Segment without lubrication in contact breaker box 96.
99, Segment with lubrication in contact breaker box 96.
100, Segment with lubrication in contact breaker box 97.
101, Segment with lubrication in contact breaker box 97.
106, Locking ring for holding contact breaker box 97.
107, Timing lever fitting over the segment box 97 (only for magnetos with variable ignition).
108, Screw for fastening the timing lever ring 107.
110, Watertight end cap on contact breaker box 96 or 97.
111, Nut for fastening the short circuiting cable.
163, Cage with steel balls suitable for both ball races.
191, Complete contact breaker for left hand magnetos.
192, Complete contact breaker for right hand magnetos.
193, Contact breaker disc only with flat spring 198 for left hand magnetos.
194, Contact breaker disc only with flat spring 198 for right hand magnetos.
195, Bell crank lever for left hand magnetos.
196, Bell crank lever for right hand magnetos.
197, Fibre piece in bell crank levers 195 and 196.
198, Flat spring for pressing down the bell crank lever.

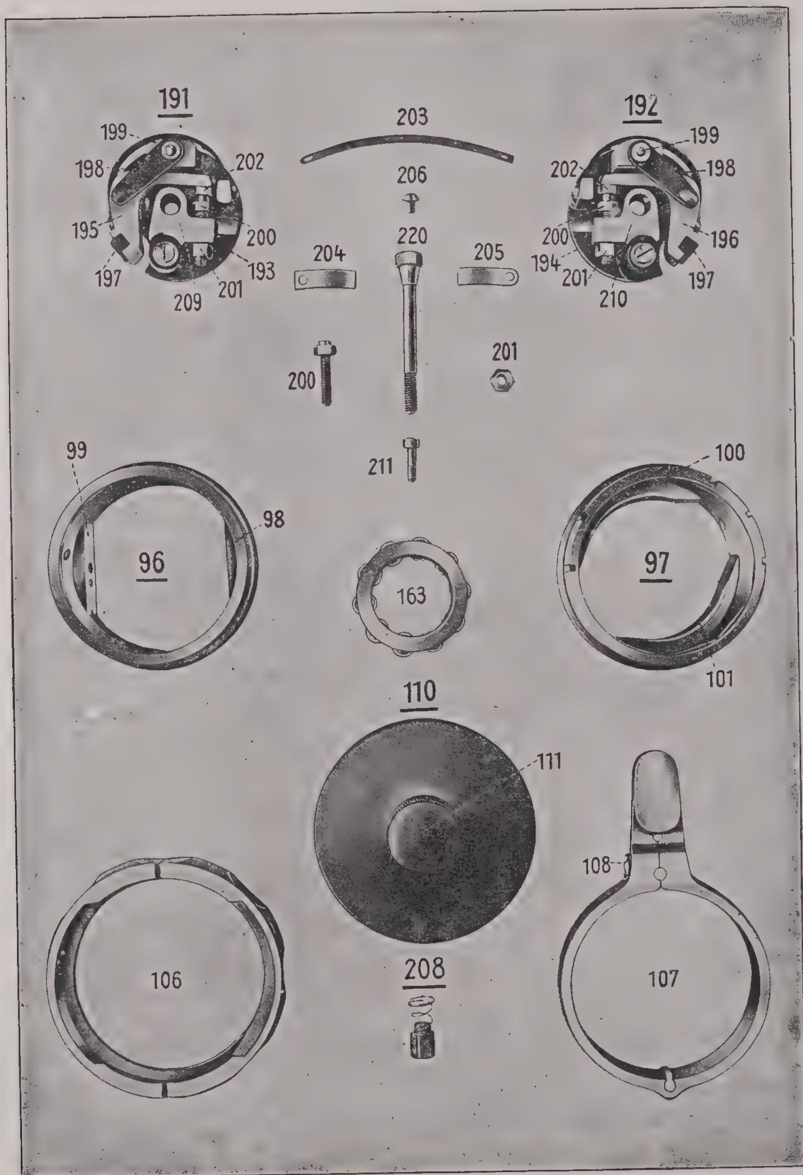


Fig. 152.—Magneto Spare Parts.

199, Washer for flat spring 198.
200, Long platinum screw on contact piece 209 or 210.
201, Locking nut for platinum screw 200.
202, Short platinum screw on bell crank lever 195 or 196.
203, Flat spring for bell crank levers 195 and 196.
204, Strengthening spring on post of contact breaker disc.
205, Strengthening spring on bell crank levers 195 and 196.

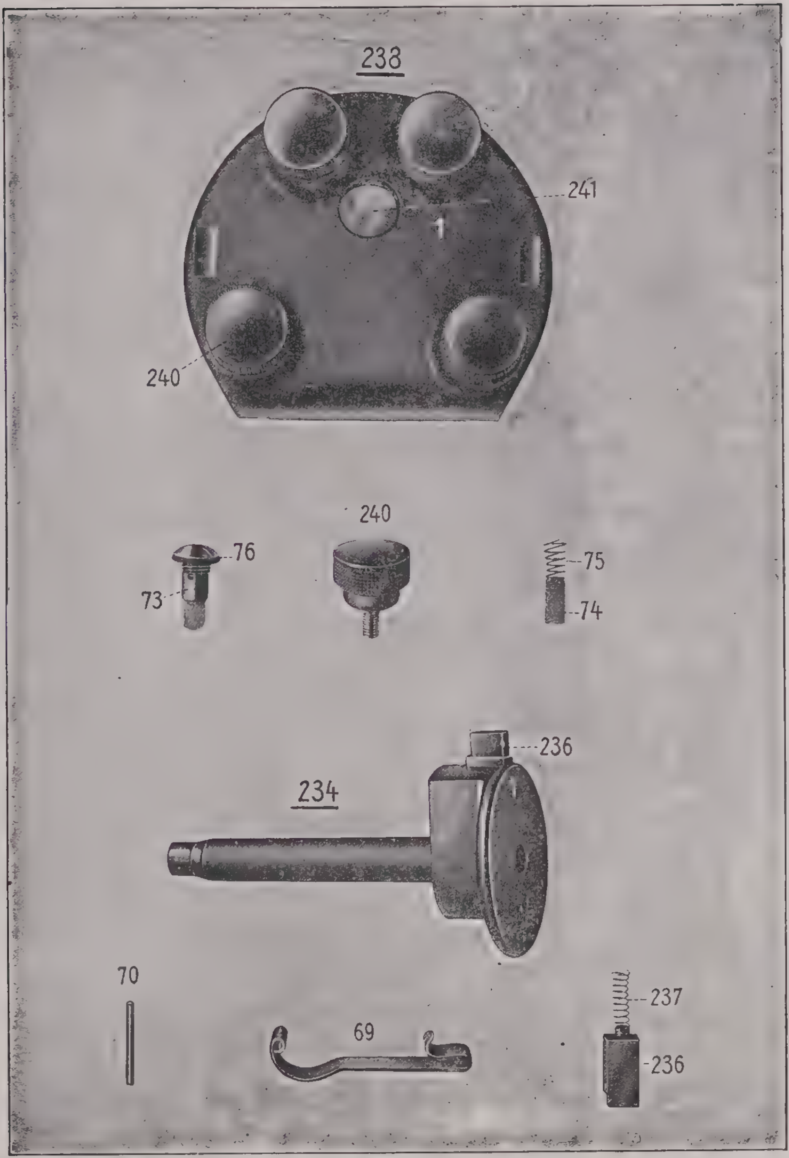


Fig. 153.—Magneto Spare Parts.

206, Fastening screw for flat spring 203.

208, Carbon brush and spiral spring on the back of contact breaker 191 and 192.

209, Contact piece for contact breaker 191.

210, Contact piece for contact breaker 192.

211, Fastening screw for contact piece 209 and 210.

220, Contact breaker fastening screw.

The third set of parts are also of great importance. They belong to the distribution system, which requires attention sometimes, and it is as well to become familiar with the parts and their names (Fig. 153).

Distributor Disc and Distributing Piece

69, Fastening spring for distributor disc 238.
70, Fastening pin for flat spring 69.
73, Oil wick screw with felt wick for spindle of distributor gear wheel.
74, Oil wick without spiral spring.
75, Spiral spring.
76, Leather washer for wick screw 73.
234, Rotating distributing piece complete with carbon and spring 236 for right hand magnetos.
236, Carbon brush for distributing piece.
237, Spiral spring for carbon brush 236.
238, Complete distributor disc with nuts for fastening the cables to the sparking plugs.
240, Insulated terminal bolt.
241, Mica plate for inspection window in distributor disc.

For the other magnets largely in use, the D3, 4, 6, the component parts are shown in Fig. 154.

Parts of the Magneto Case, Dust Cover, Distributor, and Clamp

10, Carbon brush with spiral spring for carbon holder 11b.
11b, Carbon holder without thread, with carbon 10.
12, Complete connecting bridge with carbon holder (brass) together with insulation piece and lock spring.
13, Carbon for brass holder on connecting bridge 12.
14a, Rotating distributor piece with carbon and spring.
15, Carbon for rotating distributor piece.
16, Distributor disc without screws.
21a, Dust cover with ball clip fastening, without any other parts.
22, Ebonite cover for distributor disc 16.
23, Complete triangular clamp for the distributor disc together with brass connecting piece and spring.
24, Millet nut for switch wire.
25, Spring for brass cap 26.
27, Brass block for spring 25.
28, Bolt for fixing spring 25.
36, Long screw for front end plate.
37, Short screw for front end plate.
38, Oil cover for backside end plate.

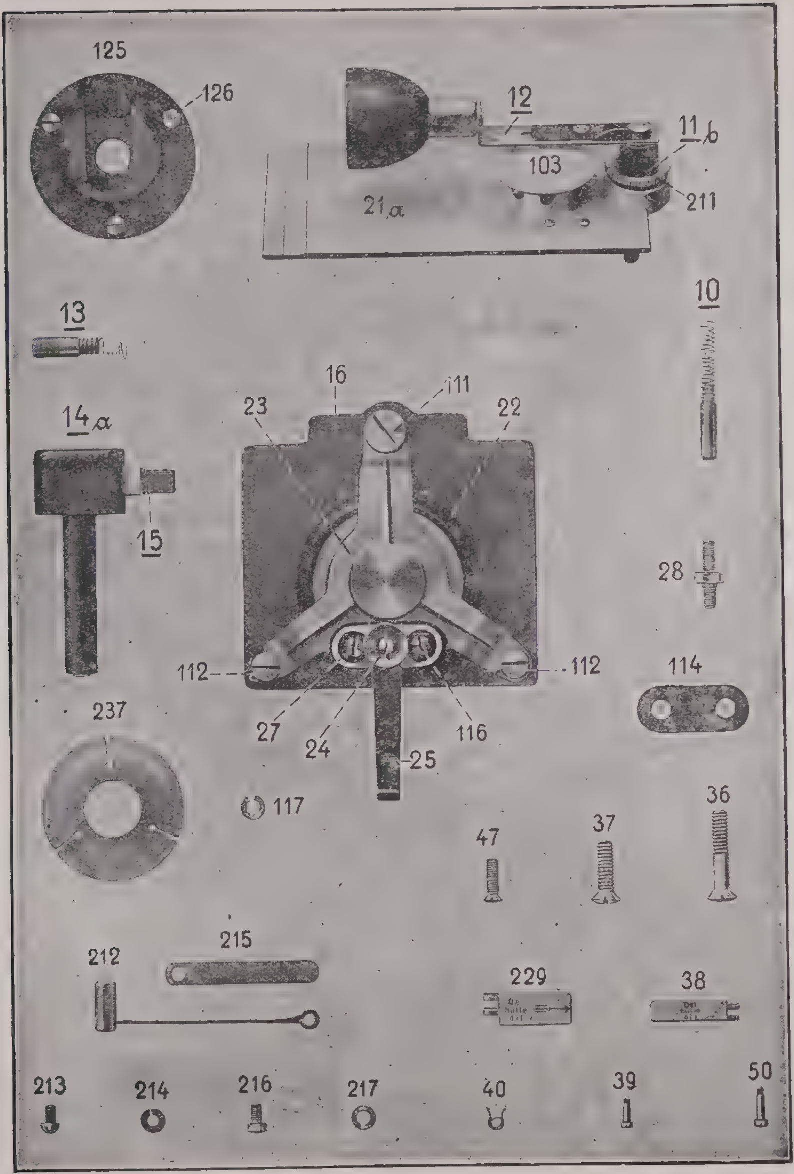


Fig. 154.—Magneto Spare Parts.

39, Fastening screw for oil cover 38.

40, Spiral spring for oil cover screws 39 and 50.

47, Screw for fastening the cover of the backside end plate.

50, Fastening screw for oil cover 229.

103, Steatite cover for safety gap together with electrode.

111, Top screw for distributor disc and clamp.

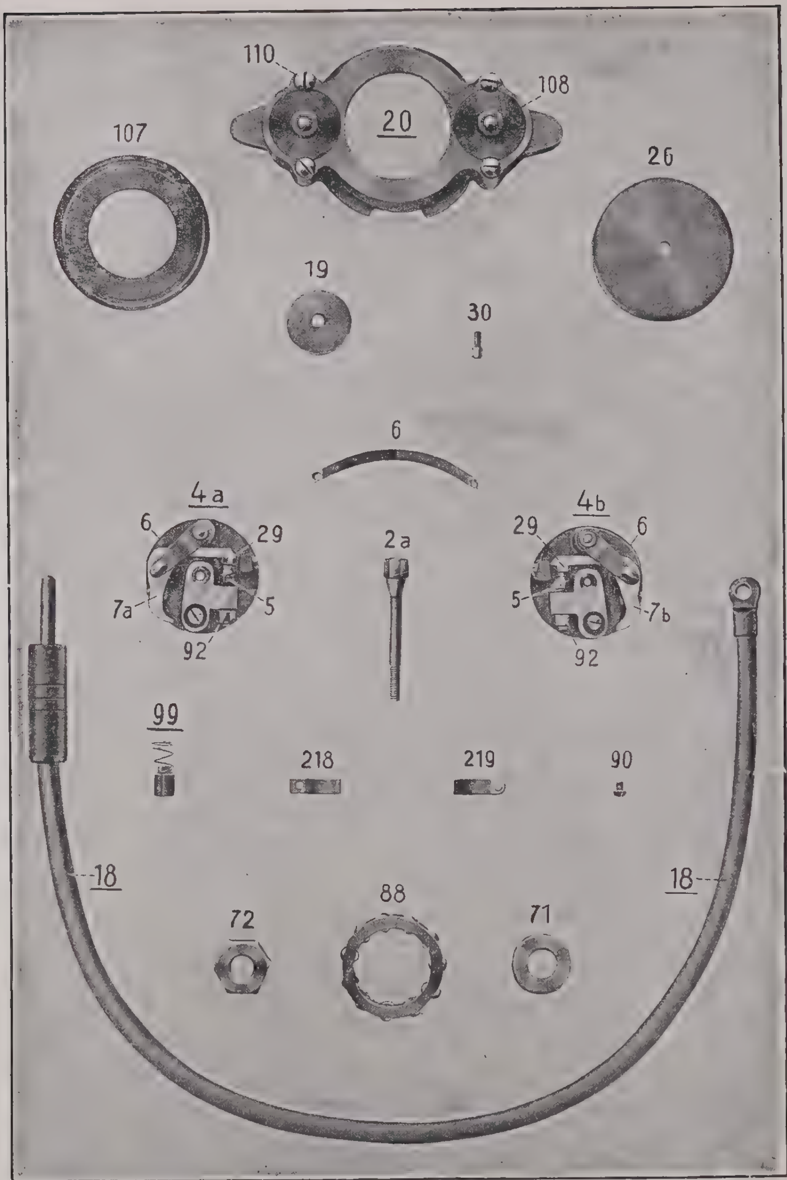


Fig. 155.—Magneto Spare Parts.

112, Bottom screw for distributor disc and clamp.
114, Insulating plate for connecting piece 27.
116, Fixing screw for connecting piece 27.
117, Washer for spring 25.
125, Ebonite catch plate.
126, Fastening screw for catch plate 125.
211, Brass nut on dust cover 21a for fastening carbon holder 11b.

212, Body carbon with cable for base plate.
213, Screw for fastening body washer to base plate.
214, Washer for screw 213.
215, Flat spring to keep body carbon 212 in position.
216, Fastening screw for flat spring 215.
217, Washer for screw 216.
229, Oil cover for front end plate.
237, Spring plate between cover 22 and clamp 23.

The more important parts, the timing lever and contact breaker, with all their screws and parts separated, are shown in Fig. 155.

Timing Lever and Contact Breaker

2a, Contact breaker screw.
4a, Complete contact breaker for left hand machines.
4b, Complete contact breaker for right hand machines.
5, Long platinum screw.
6, Contact breaker spring.
7a, Contact breaker bell crank lever for left hand machines.
7b, Contact breaker bell crank lever for right hand machines.
18, High tension cable No. 5, 800 mm. long, with terminal, brass plug, and insulating sleeve.
19, Fibre rollers for advance and retard lever 20.
20, Complete timing lever with fibre rollers.
26, Brass cap for timing lever 20 together with carbon and spring.
29, Short platinum screw.
30, Stop screw for timing lever 20.
71, Washer for spindle cone $\frac{3}{8}$ inch.
72, Nut for spindle cone $\frac{3}{8}$ inch.
88, Cage with balls suitable for both ball bearings.
90, Screw for contact breaker spring 6.
92, Nut for long platinum screw.
99, Carbon brush and holder for the contact breaker.
107, Insulating ring for brass cap 26.
108, Cover for fibre rollers in advance and retard lever 20.
110, Fixing screw for cover 108.
218, Strengthening spring for bell crank lever 7a and 7b.
219, Strengthening spring on projecting brass lug of the contact breaker disc 4a and 4b.

CHAPTER IV

Engine Faults and their Remedies

Failure of compression is the next worst fault after those in carburation and ignition from which stoppage or loss of power arises.

Of course actual breakage of engine parts occur; many of its parts are subject to great stresses, and a slight flaw in materials soon leads to a breakdown. This does not often happen, but when it does happen there is no road repair possible for broken gear wheels, or a broken connecting rod or piston, or a cracked cylinder.

But many of the causes which bring about loss of compression may be remedied by the owner or chauffeur. It is a defect which will be detected when the engine fails to exert the normal resistance to "cranking," and arises principally from wear or pitting of the valves and faultiness of joints between carburettor and inlet valves.

If any single joint is faulty it will admit air when suction takes place in the induction piping, and the air so admitted will, first, upset the proportions of the mixture. Then, if the trouble be from faulty valves, the piston will not get the full benefit of the explosion and so the efficiency of the engine will be obviously and seriously diminished.

Poor compression may also arise from a valve stem having become bent, so that the valve "seats" imperfectly. In this event, the valve stem should be trued-up with a few light taps of a hammer, the stem being laid on a hard, plane surface meanwhile.

Leakiness of joints may be remedied by the fitting of new washers.

No partial measures will do for an internal combustion engine. Every joint must be a joint, absolutely gastight, even under pressures of 100 to 150 lb. per square inch, if the engine is to give satisfaction to its owner and do credit to itself.

Sticking or "gumming" of inferior oil after a period of rest, especially in cold weather, often causes the piston rings to cling to the cylinder walls, so that the engine becomes very difficult to turn (by means of the starting handle). When this is so a small quantity of paraffin or petrol inserted through the cylinder head plugs will dissolve the gummed oil and free the piston rings.

If the engine overheats, the most probable cause—its lubrication being efficient—is lack of water in the cooling system, or sluggishness of action of the fan, due to the belt having become slack.

Good compression depends upon two things: first, the good fitting

of the piston rings in the cylinders and the perfectly ground-in valves where poppet valves are used. Leakage may occur round about spark plugs if the packing ring is faulty.

The exhaust valve is the worst offender in this leakage trouble.

Spring rings when worn out may be tightened up by skilful drawing out by hammering them carefully, but it is really not worth while calling in skilled mechanics for such a job, and it cannot be done by a novice. Spring rings are not expensive, and are easily fitted when new. Every chauffeur should see a set of old spring rings removed and spare ones put in. He should then be set to do it himself and may be made to do it several times ; he is then able to do all that is necessary to replace spring rings. However well fitted, it will be found that at the first running of the engine the compression will be very poor, and the man who has fitted them may feel discouraged at first, but if the engine is run for a time with plenty of lubrication, the new rings will take a proper polished surface in time and become perfectly gastight. With high compression, spring rings should run for thousands of miles without failure. Many sets of rings have run over 1,000 hours with no undue signs of wear.

The valves in nearly all cases are the cause of loss of compression, and the first thing to do in case of lost compression is to grind in the valves thoroughly.

VALVE GRINDING AND LIFTING APPARATUS

We saw from a calculation in Vol. I. that valve springs require to have very considerable power, and as the valves must be lifted and the springs taken off for the purpose of examination, and for valve grinding, we must have some ready means for the job. A proper tool also greatly assists in the effective grinding of a valve. A common type of valve and stem is shown in Fig. 156. It has a slot in one end for a key to hold the spring washer. These keys are of various forms and sizes. An assortment of them is shown in Fig. 157. Great care must be taken to carefully replace the key when re-inserting the spring.

Fig. 156.—Valve Stem

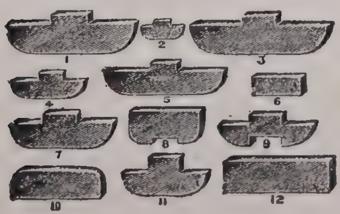


Fig. 157.—Valve Keys.

Various kinds of levers are used for lifting the spring from the collar so as to allow the valve to be easily withdrawn. We here refer to two types. Fig. 158 is a lever with two

jaws to go under the spring end, and a hinged fulcrum with a centre-punch point to rest upon the cylinder or crank casing. The method of using is quite clear in the figure.

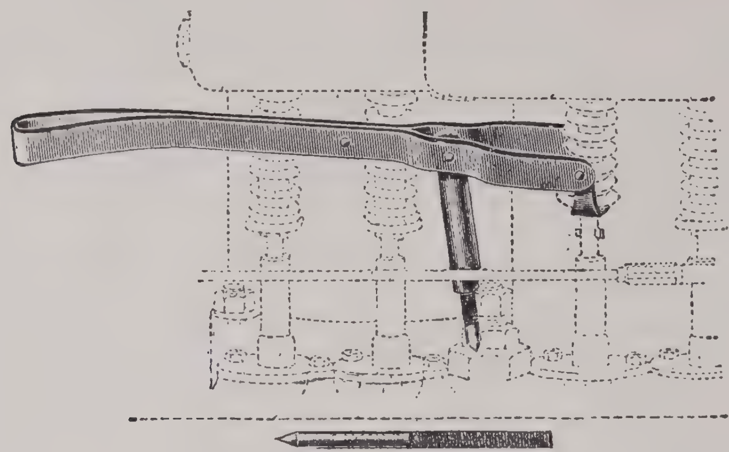


Fig. 158.—Valve Lifting Lever.

Fig. 159 shows a simple form using a plain straight lever with a chain and hook for a fulcrum. Lifting the spring, the collar key can be freed by taking out the key. The spring and the collar can then be removed.

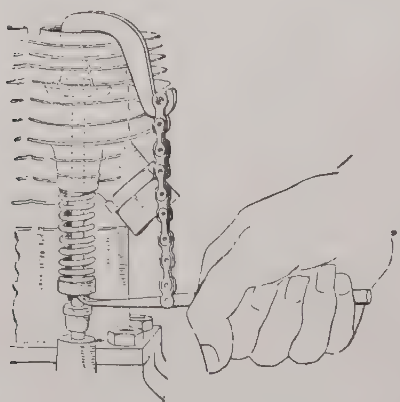


Fig. 159.—Valve Lifting Lever.

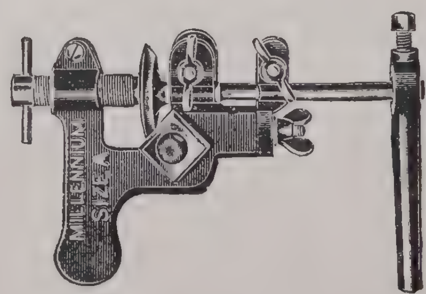


Fig. 160.—Valve Cutter for Truing.

If the valve faces and valve are very badly pitted and worn, it may be necessary to true them up. Tools for this purpose are now available. Fig. 160 shows the sort of tool supplied by Messrs. Brown Bros. for the purpose. The success in using this tool depends upon the valve spindle being dead straight and true and the valve dead true with the spindle when centred against the lower feed screw. Assuming the truth of the spindle, the cutter is brought to touch the valve face by adjusting it to the same angle as the face. When it is properly adjusted it will be

seen to have its cutting edge parallel to the face. The tool is held firmly in a vice and the spindle driven round by hand, while pressure is brought to bear by the feed screw.

Another tool for facing valve seats is shown in Fig. 161. It consists of a boring bar and head with cutters of various forms for different kinds of valves. The facing of valve seats is not so much necessary as facing the valve face, for the valve face suffers most in use.

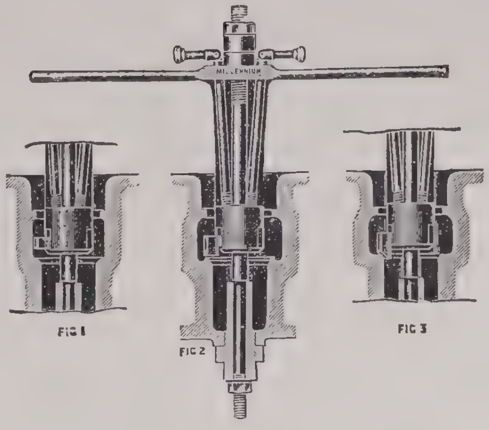


Fig. 161.—Valve Boring Bar.

Grinding the valves may be done by hand and a screwdriver as shown in Fig. 162, a view of a Humber engine with valves exposed. The driver is used to twist the valve with an alternately right and left rotary motion. Very fine emery powder mixed with water may be used for the grinding, or it may be mixed with thin oil, and sparingly applied.

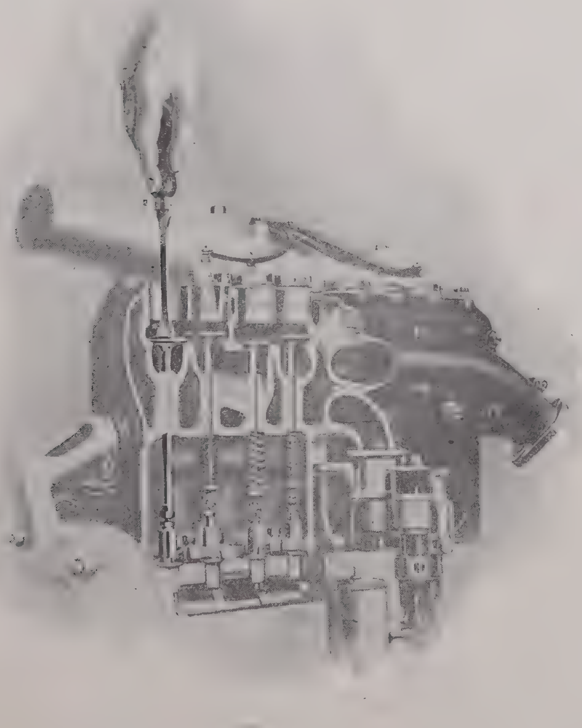


Fig. 162.—Valve Grinding by Hand.

After grinding the emery should be very carefully removed by washing out.

Grinding by hand is trying work on the wrists; it is better to use a tool such as Fig. 163. This tool gives an alternately right and left motion to the valve by simply turning the handle shown. It has two bevel wheels on the shank of the driver, and one driving bevel wheel with half the teeth cut away. The teeth left on the wheel engage with the two bevels alternately driving in

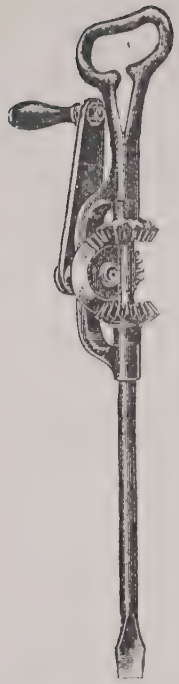


Fig. 163.—Valve Grinding Tool.

opposite directions. Having ground in the valves and closed them up again, it will be generally found that the engine compression is now all right.

Sometimes, however, there may be a leakage still to find and remedy. The spark plug joint in the valve cup may leak, and the joint of the valve cup may also leak. Many valve cups are like Fig. 164, in which the spark plug C is screwed into the cup A, with a joint at B and D.

A new packing ring of copper and asbestos will remedy these leaks.

A decompressor is sometimes used on cylinders, generally screwed into the exhaust valve cup, thus providing another two joints for possible leakage. These should also be attended to in case of lost compression. The forms of decompressors are many; one is shown in Fig. 165. They are intended for use on larger cylinders, which are difficult to turn round by handle for starting, and this is made easier by reducing the compression.

This compressor is adaptable to any engine, and provides an auxiliary chamber which, when opened to the combustion chamber, adds its capacity thereto. The larger the combustion chamber the less the pressure of compression. It can be made with a screw large enough to fit the screw of the cup and so make only one joint. It is opened or shut by a quarter turn of the lever opening or shutting the valve shown.

When taking out valves for examination or grinding, care must be taken to mark the cups and valves, and the seats to which they belong, so that they will be replaced as they were originally.

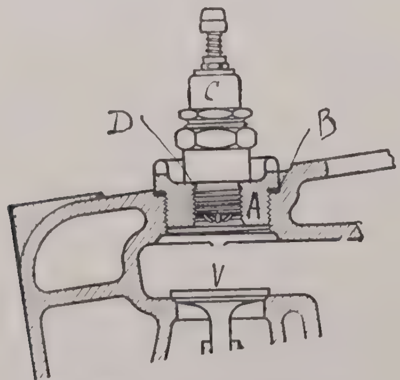


Fig. 164.—Valve Plug Packing.

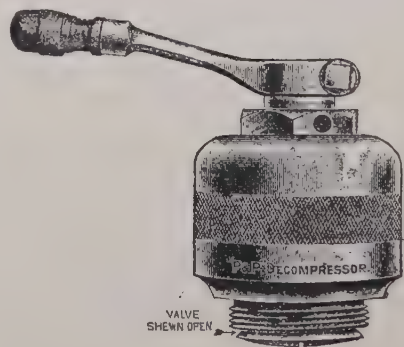


Fig. 165.—Decompresser Valve.

Sometimes they are all marked by the makers and sometimes not. The careful man always looks for marks on anything he is about to remove, so that he may be able to put it back again as it should be.

A case of failure of an engine to run after the owner had overhauled it himself recently arose from this neglect. In putting up the connecting rod and piston he had not attended to the marks on the rod. The rod was not symmetrical, one side of the big end projecting farther from the centre line of the rod to fit the crank pin, which was slightly to one side of the vertical centre line of the piston. It was plainly marked, but these marks had not been noticed. Consequently when all was assembled and ready for a trial, the piston and connecting rod jammed hard and a start could not be made, which was lucky, for if it had the rod or wrist pin or something would have bent or broken. Upon careful examination, after taking the engine all to pieces, and attending to the marks as advised by the makers, the mistake was found, and the engine reassembled went better than ever.

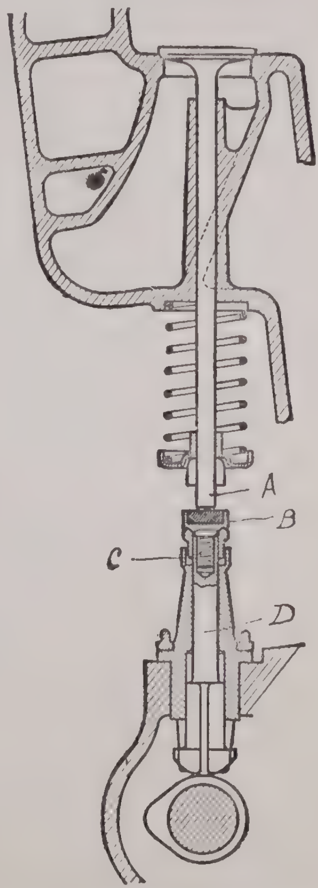


Fig. 166.—Tappet Adjustments.

A bent stem of an inlet valve may cause loss of compression by sticking up the valve and not allowing it to close quickly. The remedy is to free the valve by straightening the stem.

Again, the valve may be prevented from closing by the tappet plunger or valve stem being too long and not allowing the valve to close.

The Wolseley tappet will illustrate this: see Fig. 166, from which it will be seen that it consists of a plunger B having a screw C, adjusting at the point of engagement with the stem A of the valve. The plunger is prevented from rotation by flutes cut upon the sides, which slide in corresponding slots in the guide. The valve is quietened by the use of a fibre washer B in the end of the plunger.

If A and B are set too close the expansion of the stem by heat may stick up the valve as the ends A and B remain in contact.

All tappets should have adjustable ends as shown, or on some similar plan; when too wide apart the plunger leaves contact with the stem too early. The consequence is, the valve is dropped on its seat violently and the valve not only makes a noise, but wears rapidly and may even break. The tappets should just be clear when the valve is seated by the thickness of writing paper of thick quality.

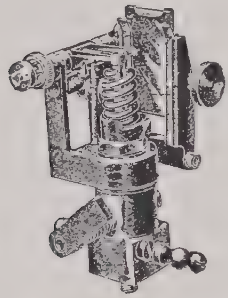
The next subject for examination in case of loss of power is the exhaust system, its pipes, and the silencer. These suffer from choking up by grease and carbon, and soot from the lubricating oils in the cylinders.

This choking occurs always at the farther end of the exhaust piping near the silencer, and in the silencer itself. The great heat of the exhaust prevents choking near the engine.

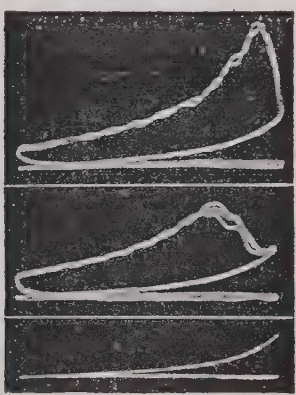
This choking sets up back pressure and often causes blowing out of exhaust joint packings.

Cleaning out the exhaust piping and silencer is no easy job. The pipes are often crowded and not easily taken apart.

Some silencers are not designed for cleaning; in fact, it is cheaper sometimes to discard a choked silencer and fit on a better one.



The indicator to screw into cylinder.



The microscopic tracing and the enlargement of the indicator diagram.

Fig. 167.

Almost any kind of a silencer will produce silence, but any kind of a silencer will not silence without back pressure, and give free access for cleaning out.

A choked exhaust system, unless it has been originally designed with a view to its being readily opened up for cleaning, and as readily put together again, is a job for the professional motor doctor to attend to.

The present writer has made a special study of motor exhaust systems. If the truth were told about the silent cars, and their inefficiency in exhaust matters, it would surprise owners as to the amount of fuel wasted in exhausting the engine.

One reason why loss by exhaust back pressure is overlooked so much is due to the difficulty of measuring its amount. In large slow speed engines it can be shown on an indicator diagram, but on the quick speed motor car engine an ordinary indicator is useless. No spring indicator gives reliable results at the higher speeds.

The lavish supply of lubricating oils to the cylinders so common by careless drivers makes matters worse. The oils used split up into smoke, i.e. unconsumed carbon and heavy tarry compounds well fitted for choking silencers.

When a considerable accumulation takes place the choked exhaust gases, not able to escape quickly, rapidly heat up the silencer, and the well-known yellow and brown smoke is then emitted from the exhaust.

Not one single example of a thoroughly well designed exhaust silencer exists in practice.

Most engine makers make their own silencers and are satisfied if they obtain silence, in most cases, without much consideration for economy. Where one can do so without annoying the whole neigh-

bourhood an interesting test is to try the engine's power with and without the silencer, allowing the exhaust to bang into the air, or, better still, through a trumpet shaped exhaust pipe.

The great difficulty of obtaining indicator diagrams of high speed petrol engines has long been understood. A number of instruments have been invented from time to time for this purpose, the most successful of which is probably the optical arrangement which projects the diagram, greatly magnified, on to a screen, or enables it to be photographed. A new instrument, Fig. 167, invented by Dr. Nettmann, and made by the scientific instrument making firm, Gebruder Starzl, Kapuzmerstrasse, Munich, produces a direct tracing of the diagram on smoked glass. This tracing is of microscopic dimensions, but, when examined in an ordinary microscope, it is of ample size for all practical purposes. The instrument traces twenty-four diagrams on a slip of glass only $1\frac{7}{8}$ inch long by $1\frac{1}{8}$ inch wide. The indicator is screwed directly into connection with the interior of the cylinder in place of the compression tap. The drive is taken from the crank shaft by means of a small auxiliary crank and connecting rod, thus giving a positive and reliable movement. A number of other important advantages are claimed for this instrument.

WATER CIRCULATING TROUBLES

The overheating and boiling of the radiator is in most cases due not to defects in itself, but to faults elsewhere.

Defective carburation gives too much petrol, causes overheating of the radiator because the petrol in excess flames and heats the cylinder to the end of each working stroke, and into the exhaust. Defective cylinder lubrication causes overheating at the radiator. In this case the pistons work against great friction, and extra petrol and mixture are consumed in the effort to drive the engine, with the result that the cylinders are overheated, thus overheating the radiator.

In almost all cases of radiator boiling violently the indications are that there is something wrong with the engine. Of course a radiator will boil naturally if the car is run at fairly high speeds up long gradients or on long runs on hilly roads, and also in very hot climates.

The working temperature of radiators is from 180 to 200° Fahr.

Boiling of the radiator and much steaming at the vent pipe, in cars which have run constantly for two or three seasons, is due to the natural accumulation of grease from the circulatory pump ; lime from hard water used for cooling, rust from cylinder jackets, and mud from soluble substances in the water. These collect and reduce the circulation of the water in the cooling system.

The remedy is to run off the water, and fill up with a solution of water and common washing soda, 2 lb. to the gallon, and run the engine

for a few hours at moderate speed. The solution is then run off and the whole system scoured out by a pressure of water from a hose pipe.

Many engines are now run without any circulating pump, the pipes and all passages being of ample size to allow of the natural circulation due to convection, as illustrated in Fig. 168, in which the large size of the cooling water conduits are shown. The vent pipe is shown at A; it acts as the overflow pipe in filling up, and also as escape pipe for steam. Where pumps are used they should be inspected sometimes as the cause of feeble circulation of water. Pumps which have run for a long spell get clogged by various substances—little bits of waste, rags, straw. Knocking in the engine, and premature or spontaneous ignition, may be due to defective circulation of water, especially if given full gas and spark advance.

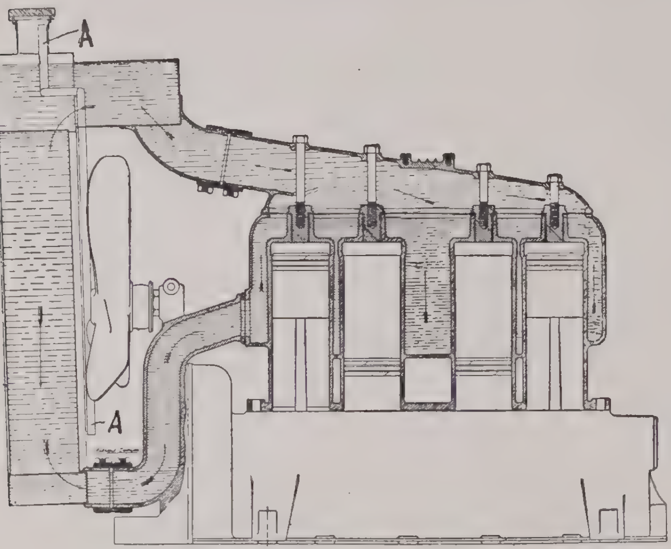


Fig. 168.—Thermo Syphon Water Circulating System.

If the spontaneous ignition goes on after the spark has been cut off, it is probably due to some small carbon flakes on the piston head, or on the combustion chamber, becoming red hot owing to the insufficient cooling and firing the mixture on compression.

Running the engine for long periods with the ignition retarded overheats the radiator.

In some early engines troubles arose from air locks or steam locks in the circulating pipes. Such a thing is impossible in an intelligently designed water circulation. Such defective and stupidly designed systems are now unknown or very rare.

Leaky circulating tubes may be repaired temporarily on the road by slipping rubber tubing over the leak if it is get-at-able; if not, a piece of tube slit up one side, slipped over the pipe, and wired on by copper wire can be applied.

Leaks in the radiator tubes may be stopped temporarily by plugging up both ends of the leaking tubes with soft wood or cork plugs whittled down to fit.

If the chauffeur or owner is handy with a hammer, leaks in radiators may be stopped, at least for a time, by careful caulking, but this re-

quires skill and experience. The wooden plug is the best remedy, put in with white lead paste; the ends should be left long enough to enable them to be pulled out.

When a leak occurs round the outside of the radiator tubes on the face of the tube plate, two metal washers may be used back and front with rubber washers to apply to the leaky face; a screwed wire with two nuts passing through the tube is used to pull the washers hard on the face and cover the leak.

In filling a radiator it is important to see that the vent pipe is not choked.

The water cooling system is subject to freezing, with disastrous results to the water jacket.

If a car must be left exposed to frost overnight or for hours during

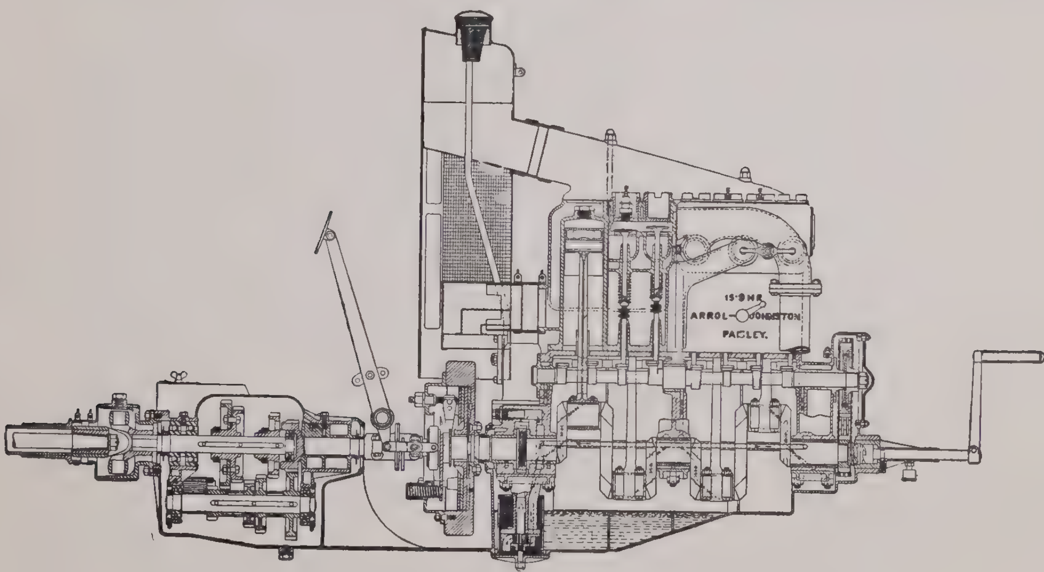


Fig. 169.—Thermo Syphon Cooling Radiator behind Engine.

the day, the water should be run out of the cylinders and system. The garage should be heated in frosty weather by a slow combustion stove or hot water pipes. Burst cylinder jackets can be patched by skilled mechanics, or welded up. It is a serious matter in any case, and requires the sending of the cylinder off for repairs.

Fig. 169 is given to show a typical engine with thermo-syphon water circulation; the radiator is behind the engine in this car. The large circulating pipes are an obvious feature.

Plate III. shows a pump circulation system in a four-cylinder engine. A is the circulating pump, C is the connecting pipe between the two pairs of cylinders; by the small pipe B the carburettor C is kept hot by hot water flowing from the cylinder outlet F to the pump inlet G.

The radiator is connected also in between the inlet of the pump G, to the outlet of the cylinder jackets F; from this it will be seen that the water passing through the carburettor does not pass through the radiator.

ENGINE MECHANISM; REPAIRS

In order to inspect and get at the crank shaft bearings and large connecting rod ends, the lower half of the crank case is movable, and can be taken off by standing the car over a pit. A chassis is shown in Plate IV. as seen from the pit, looking up to its under side. The lower half of the crank case is removed, exposing the main bearings and cranks.

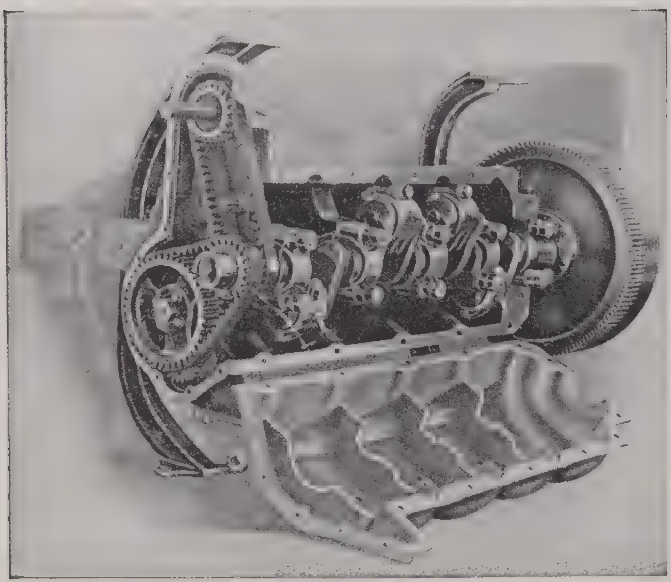


Fig. 170.—Crank Case opened out.

In Fig. 170 an engine is shown laid out for inspection and repairs inside the crank case. It is a Cadillac engine. The teeth cut on the flywheel are for the pinion on the starting up electric motor. The inspection and repair of the big ends of the connecting rods and the main bearings are thus made easy.

When an engine requires a thorough overhaul it should be removed from the chassis entirely, and in order to get at it all easily a stand has been devised for the purpose of holding the engine while turning it upside down, or on either side.

This stand is shown in Figs. 171 and 172. It possesses several very useful features, and is undoubtedly a valuable adjunct to the ordinary plant. By this means it is possible for one man to dismantle or assemble a heavy four or six-cylinder engine. When fixed by the holding down bolts the engine can easily be turned over, and, in addition, it can be held and locked in any position removed from the vertical.

Short swivelling arms connected to the main side frame support the engine. These are, of course, useful in the case of a power unit which is materially heavier on one side than on the other, it being easy so to balance the engine that despite any side heaviness it assumes an up-

right position when in the stand. The locking of the appliance is accomplished by a length of round steel, which fits into a socket cast on one of the main supports, and having at the other end a screwed thread on which two locking nuts can be moved up and down. When tightened up, these nuts hold the frame containing the engine secure from all danger of slipping.

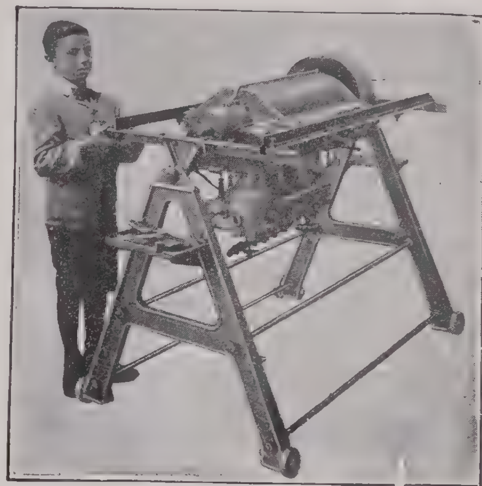


Fig. 171.—Engine Table.

A further feature of interest lies in the bearings which support the main frame. These are not fitted with a top cover, and in consequence when an engine is bolted in position it is possible for it to be lifted completely out of the frame and carried away to the testing bench or wherever it may be required. Two small trays are provided on which the workman can place his tools. The whole stand is mounted on four strong rollers.

In going about the repairs of the internal mechanism to see what has to be done to take up the slackness due to wear, we should first attack the small ends of the connecting rods and the wrist pin in the piston; both may be badly worn, but in most cases of an engine of good make only the bush in the connecting rod end will be worn. That is the reason why a bush of softer material than that of the pin is used, so that to take up wear only the bush need be adjusted to the pin, which, being of hardened steel or of iron thoroughly case hardened, should show no signs of wear for long years.

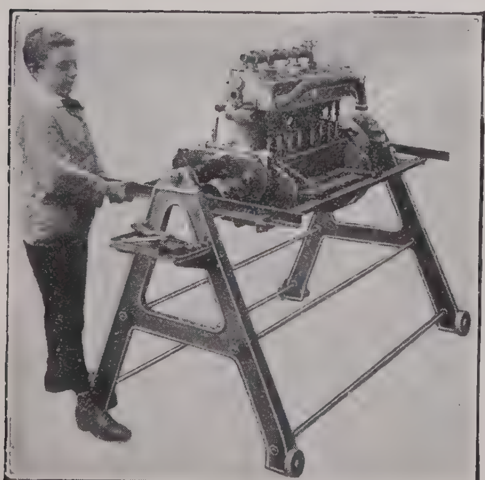


Fig. 172.—Engine Table.

In some engines of good design the bush in the small connecting rod end can be taken out and adjusted easily enough, but in most cases a new bush is very easily and cheaply put in, and makes a better job than tinkering up an old bush.

In many manuals and small books of instruction on motors a great deal is said about lapping and dressing up the crank pins and main bearings of the crank shaft. But a crank shaft and its pins and bearings is a worthless affair if it should require

any such attention within ten years of constant work. The crank shaft is (or should be) made of the finest hard tough steel obtainable, and the main bearings and crank pins should, and in every case do, have bushes of a softer material for the express purpose of taking all the wear without undue friction; even should lubrication fail, only the bushes should suffer if the crank shaft is of proper material.

We need not, therefore, consider what should be done with a shaft whose pins and bearings show signs of wear. It is a shaft of poor stuff and better replaced by a shaft of the right stuff.

A good shaft may, of course, be badly scored by grit getting into the bearings; sand and grit will score anything. But in such a case no ordinary means such as lapping will remedy scoring on the hard tough steel. The skilled lathe hand or the skilled crank grinder with a first-class grinding machine is the only resort in such a case.

It is different with the bushes or brasses. These are expected to wear. We cannot prevent their wearing by any means. Hence the necessity for providing means to take up this wear.

The chauffeur or owner of a car is seldom skilled enough as an engine fitter to properly adjust an engine's main bearings and connecting rod ends when these have worn slack. No amount of written instructions can teach how to proceed with and handle such an important job. If it is not carried out in a thoroughly workmanlike manner the engine will be worse than ever.

Many a good engine has been ruined by being overhauled and the main bearings and connecting rod ends adjusted by an unskilled man at some garage. The present writer saw a man in a repair garage scraping and filing the crank pins of a crank shaft in his efforts to make them fit the brasses. Such a procedure showed at once the man had no experience or knowledge of engine fitting.

The owner of a good engine, when he suspects the bearings require taking up, should see that it goes into skilled hands. The crank shaft may require some little attention, very skilfully, but not often. The fitter will, after seeing that the crank shaft is right, proceed to refit the brasses of the main bearings by filing and scraping. These made good, he will proceed to refit the connecting rod ends (see Fig. 173).

This work cannot be done hurriedly and deserves to be well done. An engine refitted in this way by a skilled hand is as good as new, but refitted by an unskilled hand it is generally spoiled.

Some engines are fitted with fusible white metal bearings. Engineers of great experience and knowledge are divided in opinion regarding the use of white metal bearings. No doubt it may melt and run out of a hot bearing, and so save it from a seizure, but in such a case it may allow the shaft to be bent, due to the loss of support at the run out bearings.

The refitting of white metal bearings is a more particular job than refitting brasses, and is done by men specially trained for the work.

Finally the combustion chamber and piston heads should be examined and cleaned of any deposits of carbon, burnt oil, and scale. These sometimes cause trouble in ignition.

An engine may be difficult to start after it has stood a long time idle. This is generally due to the gumming or oxidising of oil in the cylinders.

The remedy is to inject first a small quantity of paraffin oil into each cylinder, and allow it five to ten minutes to soak in, then inject some

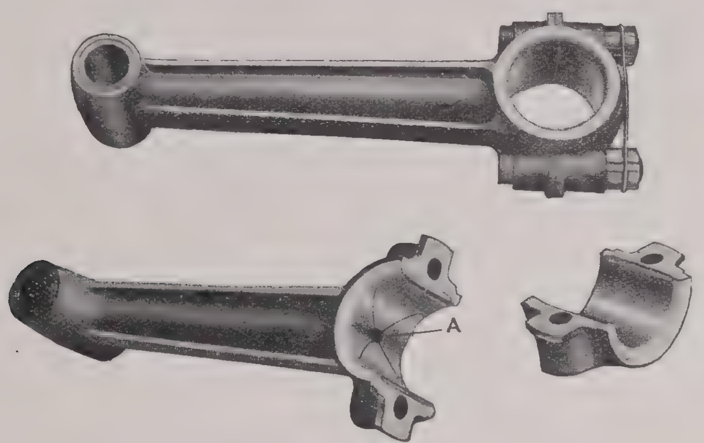


Fig. 173.—Connecting Rod Ends.

good cylinder oil in each cylinder; on cranking round it will then generally start off, if the carburettor is a good one. But if the carburettor fails to give a good mixture when all is cold and at the slow starting speed, it will be necessary to inject petrol into the cylinders to get an easy start.

Tickling the carburettor float serves the same purpose. It causes an overflow of petrol into the carburettor, and the surplus is more readily drawn into the cylinders than through the petrol jet.

CLUTCHES AND THEIR TROUBLES

We have seen from the descriptions of clutchcs that there are two classes, the leather cone clutch and the steel disc clutch; both have their faults and failings.

Good easy starting of the car depends on the clutch slipping, and this slipping on a leather cone means wear and tear, so that in time the leather becomes thin and allows the rivets which hold it in place to make contact with the wheel. These rivets may thus cause trouble by fiercely gripping. A new leather is the remedy; the old leather can be removed by chipping and pinching out the old rivets.

The old leather will serve as a pattern for a new one, or a paper pattern may be cut from the clutch.

A leather may become fierce; that is to say, it will not slip gradually into contact, but takes hold suddenly. This is generally due to the glazing and hardening of the leather face by continual use. The remedy is to scrape the leather surface, so as to expose the leather fresh faced to the clutch. A rasp file, if carefully used, is the best tool, but a common scraper will do. After the surface is clean, the leather should be made damp evenly all round by applying a little water with a brush. The leather should only be moistened, not soaked in water. Allowing the water to sink in, castor oil, heated by placing it in a tin can and the tin can in hot water, is then liberally applied. One coat after another, with intervals to allow them to sink in, probably four or five coats of oil.

A very small quantity of black lead (plumbago) may be thinly rubbed on the surface for a finish.

The clutch may slip at first too easily, but a day or two's use will make it all right, or the clutch spring may be tightened up for the first few days, and then relaxed to the normal.

But a fierceness in the clutch may not be due to the leather, but something else. Some of the moving joints or collars or pins in the clutch operating mechanism may be jammed or binding; and the motion of the clutch, instead of going in steadily and easily, jumps in by a series of jerks, and all at once jerks into clutching suddenly. The same sort of stiffness about the clutch gear may prevent it going in far enough to take proper hold, and it will slip badly. Before condemning the leather we should therefore see if the lever and springs and joints are all freely working. The forked lever may be bent, twisted, or worn unequally, this skewing the collar and binding the motion.

A slipping clutch—that is, one which will not hold on full power—must be attended to at once, otherwise the leather will be burnt and spoiled on the face. The spring must be tightened up if possible. If not possible, then a little oil may make it take better hold. If the remedy cannot be immediately applied, the speed of the car should be kept moderate until the garage or a repair shop is reached, by running the engine quickly and with the low gear on.

It may be mentioned that the cone with its leather when in clutch with the flywheel is part and parcel of the flywheel, and if it is not as carefully balanced as the flywheel usually is, it will cause vibration at high speeds. The cone of the clutch should be perfectly balanced, and if an engine does not vibrate with the clutch out, but vibrates with the clutch in, it may be taken that the clutch is out of balance.

Metallic disc clutches are now almost universally used, and are more reliable than the plain leather cone clutch. The trouble they give is mostly due to the abuse of the clutch by allowing it too often and too much slipping, thereby working the oil from between plates; they then seize and lock. Spare clutch plates are the best remedy. Take the

clutch apart, remove the plates and discard all of them with roughened surfaces, and replace by new ones.

Occasionally the oil should be drained from the plate clutch and fresh oil filled in, but before filling in the fresh oil it is advisable to run in some paraffin oil and move the engine round for a time to work it in; then drain off the paraffin, which will carry with it any dirt. This washing out with paraffin is of great advantage.

COMPONENT PARTS OF TRANSMISSION GEAR

The mechanical transmission gear, consisting of the various couplings, change speed wheel gearing, cardan shaft joints, and differential gears, is all subject to ordinary wear and tear and breakages. It would take too much space here and be of little use to detail the wearing out and remedies for these parts. As a rule they are well calculated for their work, and well made, so that, bar accidents and with fair attention to lubrication, they require little attention, and run without trouble for very long periods. When they do break down it is a case for the motor engineer and skilled mechanic.

The differential gear and the change speed gear run in oil. It is therefore very necessary for the chauffeur to take notice of any leakage of oil from the differential gear case and change speed gear case and remedy it. Otherwise it might run dry on a long run and cause a stoppage on the road.

Broken teeth in gear wheels may be replaced by screwing in two or three steel wire pegs, same diameter as teeth thickness as shown in Fig. 174 at A. The pegs are to be of same height as the teeth, and carefully bevelled off as at B, to the same curve as the teeth, by a fine file.

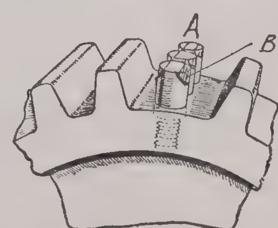


Fig. 174.—Gear Wheel Repair.

The nomenclature of motor car gearing is a subject which has recently been discussed in *The Autocar*. It is a matter of importance that each part should be known to all people by the same name, and we cannot do better than adopt the names as given by *The Autocar* when referring to the transmission gearing.

Before the days of the direct drive gear box there was no difficulty in naming the shafts in what was then termed the Panhard type of gear box, the Panhard type signifying a gear box with two main shafts, on one of which was a sliding sleeve with one set of gear wheels formed thereon. In this type of gear box the shaft which received the drive from the engine and clutch shaft was naturally called the primary shaft, whilst that which took the drive from the primary shaft and conveyed it to the propeller shaft (or the counter shaft if the car were chain driven)

was termed the secondary shaft. But with the introduction of the direct drive it became less easy to identify the main driving shafts. The first shaft in the gear box of this type is usually quite short, and carries the driving dogs or internal pinion of the direct gear, and also one of the constant mesh gear wheels used when any indirect gear is engaged. This first short shaft has been, and still continues to be, variously termed. For instance, intermediate shaft, primary shaft, clutch shaft, and driven shaft. The other two shafts in the gear box have also been variously termed, that carrying the sliding sleeves and conveying the drive to the propeller shaft being also sometimes called the primary

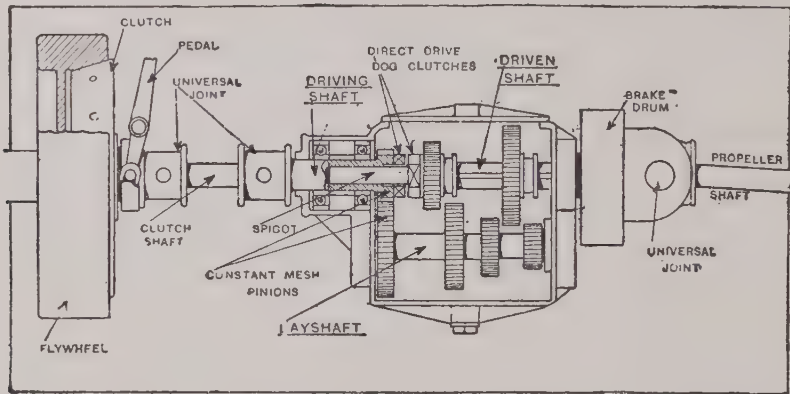


Fig. 175.—Diagram of Transmission from Flywheel to Propeller Shaft, Indicating the Names and Positions of the Various Shafts and other Details.

shaft; others have termed it the secondary, others again the tertiary shaft. The shaft carrying the fixed pinions and the driven constant mesh wheel has also been termed the primary shaft, as well as, sometimes, lay shaft, secondary shaft, and so on.

Herewith is a diagram (Fig. 175) of the usual type of gear box, indicating the three shafts already referred to, and showing clearly the names by which these are to be identified so far as *The Autocar* is concerned. The short shaft taking the drive from the engine or clutch shaft is termed the driving shaft, the one carrying the driven constant mesh wheel and the fixed pinions being the lay shaft, whilst that carrying the sliding pinions and forming the rear extension of the driving shaft is the driven shaft.

If this nomenclature be followed there can never be any doubt in any one's mind as to which shaft is meant. On the direct drive the power is taken from the engine to the propeller shaft through the driving and driven shafts, these, of course, being connected up for the time being by the dog clutches or their equivalent. On indirect gears the drive passes from the driving shaft to the lay shaft, and thence to the driven shaft. The short spindle carrying the reverse pinions, usually at the bottom or side of the gear box, will, of course, be known as the reverse pinion shaft.

BRAKES

The brakes are of great importance and must be kept in good repair and efficiency. They are of two kinds—brakes with lined faces of soft material such as leather, "Raybestos," or "Ferrodo," and brakes with metal to metal faces.

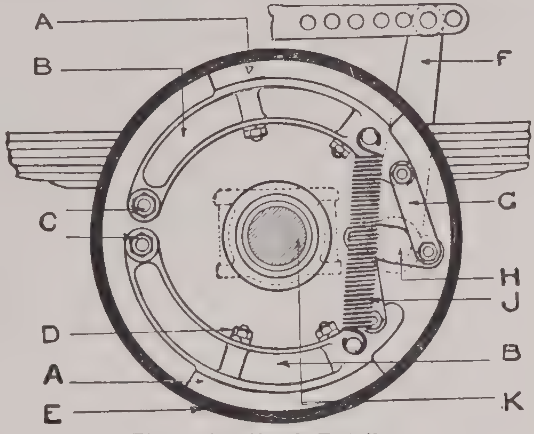


Fig. 176.—Clutch Details.

The metal to metal is the better brake, for the reason that the heat necessarily generated by the friction of the brake is the more readily dissipated.

They are also of the inside variety and outside variety. In the former the brake blocks are inside (see Fig. 176, BB). Two curved levers carry the blocks AA. These levers are hinged at C, and work like callipers operated by a cross lever H, and two short levers G, against the tension of a spring J, called the brake spring. The brake lever F is drawn by the hand brake lever at the driver's side to put on or off the brake. One of these brakes is applied to each rear wheel as shown in Fig. 177, wherein 8 corresponds to the rim E in Fig. 176, fixed to the wheel, and 15 corresponds to H.

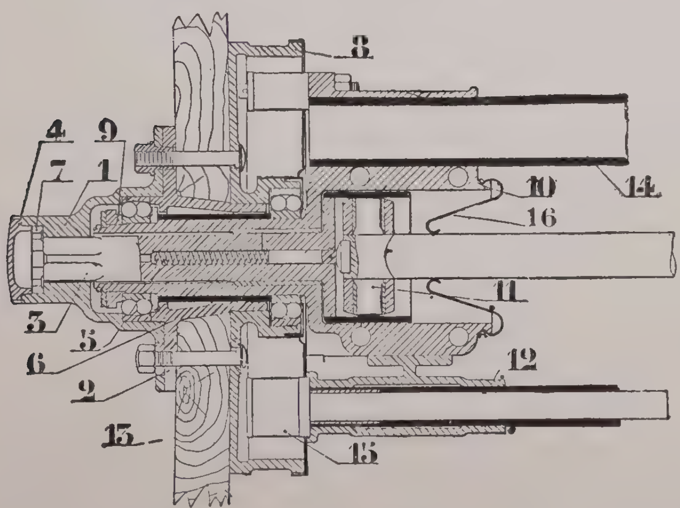


Fig. 177.—Rear Wheel Hub and Brake.

The following is a table of the parts referring to the brake only:

8, Brake drum.
11, Cardan jaw, on driving shaft.
12, Support of axle actuating brake shoes.
13, Spoke.
14, Weight - carrying axle.
15, Double cam operating brake shoes.
16, Leather dust cover.

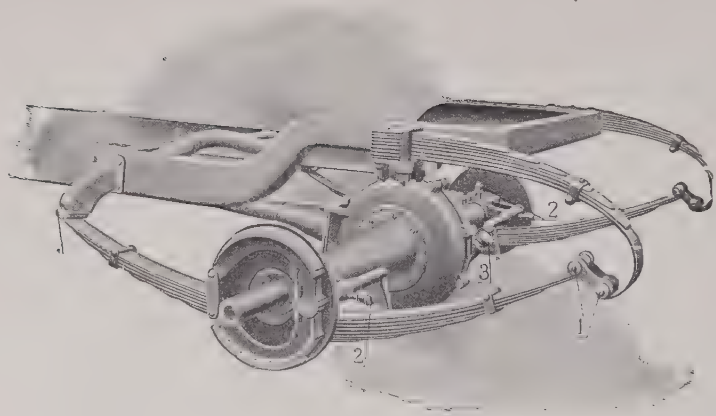


Fig. 177A.—Back Axle Brakes.

The fixed disc on the axle sleeve is better shown in the figure of the De Dion rear axle, Fig. 177A.

It is important that both rear brakes should have equal friction put upon them when they are thrown on. This is arranged for by a compensation or swivel bar (see Fig. 178). The motion of the hand brake lever is transmitted by the rod 5 to the swivel bar 4. The ends of this swivel bar are jointed to two levers 3, fixed to the cross tube 2, which operates through connecting rod 1, to expand the brake shoes.

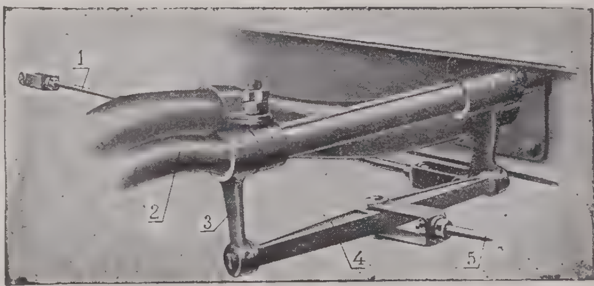


Fig. 178.—Brake Compensator.

The brake drum of the De Dion propeller shaft brake is shown in Fig. 179, of which the following is a table of parts :

1, Brake drum.
2, Propeller shaft.
3, Propeller shaft tubular casing.
4, Cage of propeller shaft fore bearing.
5, Coupling plate carrying studs.
6, Driving stud.
7, Distance spring of locking nut.
8, Screw-down grease cup.

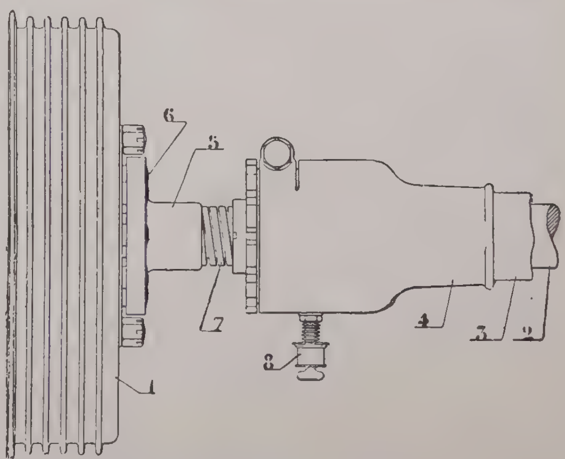


Fig. 179.—Brake Drum Cooling.

The brake on the propeller shaft is operated by the latter portion of the depression of the pedal on the right of the steering column, and remains in action only so long as that

pedal is depressed. The pair of brakes in the drums on the rear road wheel hubs are operated by a hand lever at the right of the driver. This lever is fitted with a trigger spring-pawl, working in a ratchet cut on the face of the quadrant in which the lever works. By releasing the tension of the spring, and so dropping the pawl into engagement with the ratchet, this brake can be left in operation for any desired period, so that the hand brake is that to use for long, continuous descents

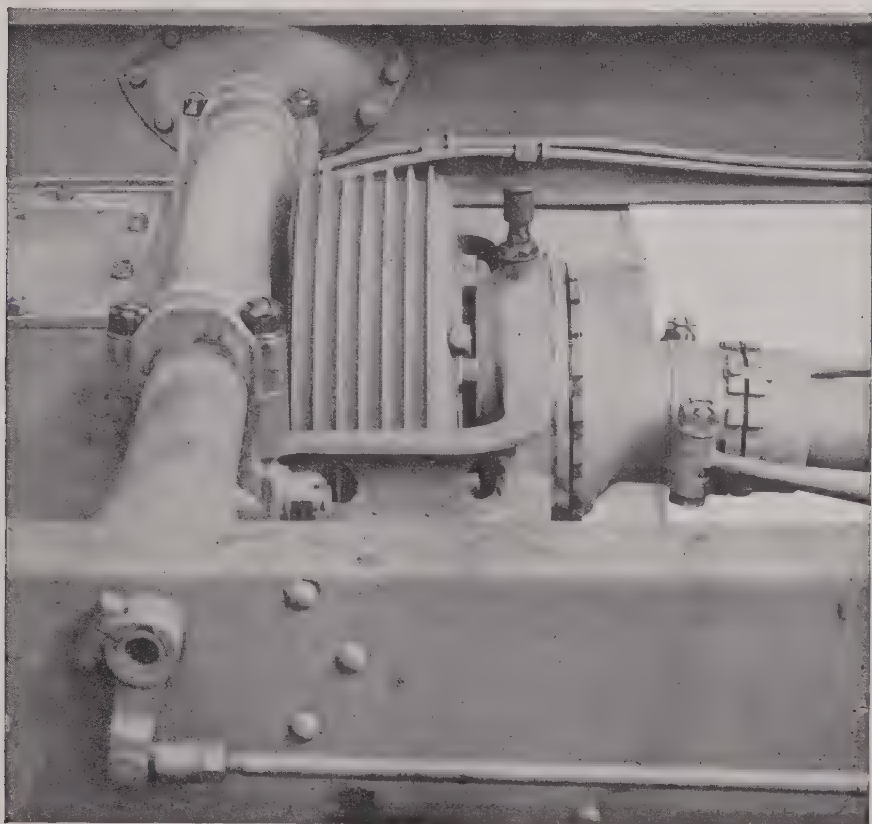


Fig. 180.—Crossley Propeller Shaft Brake Drum.

(when the use of the foot brake would be tiring, apart from the fact that, bearing on two drums instead of one, the hand brake is the more powerful of the two), or for locking the wheels of the car before leaving it unattended.

Fig. 180 shows a portion of the Crossley car chassis with the propeller brake drum in position and the side connecting rod for connecting it to the foot brake lever.

On both the illustrations of De Dion and Crossley brakes the drum is

shown with ribs or fins; these are for radiating and dissipating the heat generated. In some large cars the drum is cooled by water jacket.

The details of the propeller brake are shown in Fig. 181:

1, Sliding pinion striker rods.
2, Sliding pinion forks.
3, Lid of gear box.
4, Oil level gauge rod, passing through lid.
5, Gear locking "stop."
6, Shaft brake drum.
7, Expanding shoes of shaft brake.

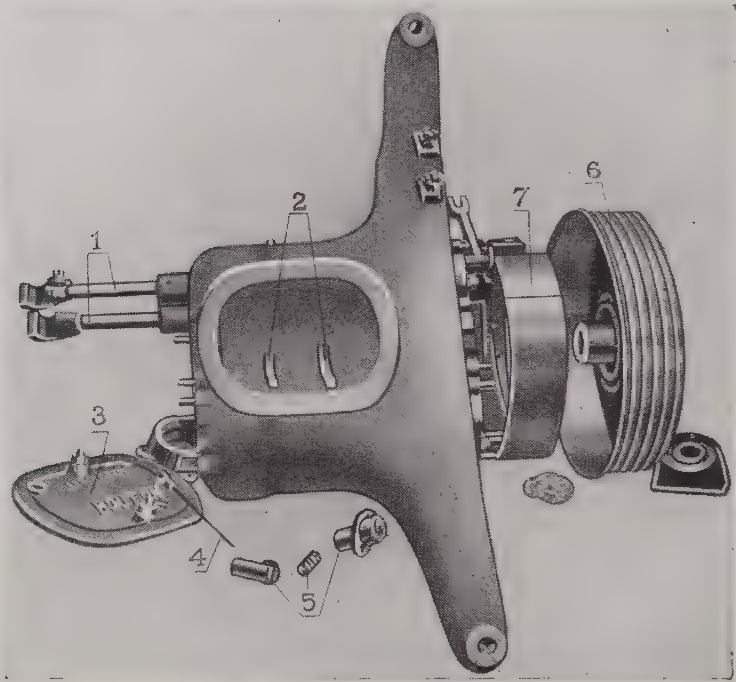


Fig. 181.

And the pedal brake and its details in Fig. 182:

1, Threaded adjustment collar, or sleeve.
2, Thumb screw locking adjustment collar.
3, Brake lead, to eccentric expanding shoes.
4, Lever operating foot brake and throttle.

There are some difficulties in applying brakes to the front wheels, for these wheels are swivelled, moving round on pivots, but brakes have been successfully applied to them in some cars.

The chief objection to the propeller shaft brake is that the whole energy destroyed by the brake is transmitted through the differential

gear and cardan shaft joints. It is better, if possible at all, to have the hand brake on one pair of road wheels and the foot brake on the other pair.

Now to attend to brakes, the chauffeur or owner must see that the brake shoes are really perfectly clear of the brake drum when the brake is released. Sometimes they are not, and the car runs under a drag all the time. All brake mechanism has a rapid adjustment somewhere whereby this can be remedied.

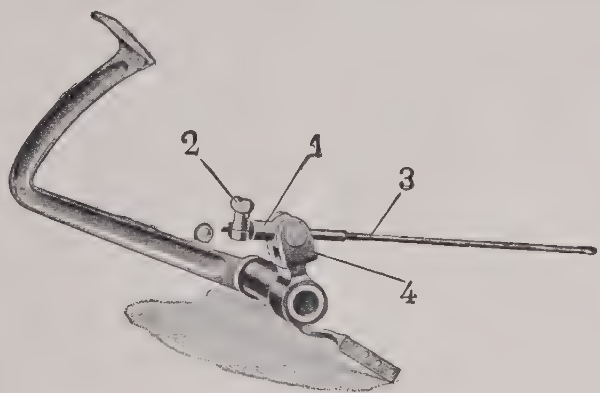


Fig. 182.

Brakes sometimes lose their gripping power due to oil from the bearings getting into them; this trouble should be looked for if brakes slip, especially on the rear brakes.

The brake gearing and shoes are responsible sometimes for a great deal of noise, due to slackness of the parts and long rods vibrating not being sufficiently supported. This can be remedied to a large extent by the addition of stays, springs, and brackets.

The brake connections should be often inspected and anything requiring adjusting or other attentions should be put right at once.

In all good cars the fixed nuts are all securely locked. Adjustment nuts are provided with lock nuts, and these should be seen to that they are thoroughly locked.

Rusting of the brake and its joints must be prevented by carefully greasing them where exposed to wet and damp.

There is a tendency among novices to "drive on clutch and brakes." To disengage the clutch and jam down the foot brake is excusable if one suddenly encounters another car careering wildly round a corner on its wrong side, or in other emergency, but for the control of the car in ordinary circumstances the use of the decelerator pedal, the hand throttle lever being left as it is, to set the speed to which the engine will return when the pedal is released, should amply suffice.

The engine used by a "throttle" driver will last in good condition infinitely longer than will the engine driven by one of the "clutch and brake" order.

To stop a car one must check or arrest its motive power. The best place at which to do this is, obviously, at its source, by the diminution of the fuel from which it is produced.

To bring the car to a standstill one closes the throttle—by means of the decelerator pedal—disengages the clutch, and gradually applies the

foot brake. The moment the road wheels come to rest, the clutch being disengaged, the change speed lever should be put into the neutral or "out of gear" position, and the hub brakes should be applied by means of the side lever. If the car is to be left stationary for more than a few minutes the magneto switch should be moved to the "A" or "Off" position, Fig. 183, when the engine will stop.

Fig. 183.

For momentary halts the engine may be left running, the hand throttle lever being used to set it at its minimum running speed, but (especially in the case of an engine starting so easily as that of the De Dion Bouton) it is always advisable to switch off before leaving the car unattended. There is always the possibility that somebody may happen to come along, ease off the side brake, joggle the change speed lever into a gear meshing position, and set the car running amok! This has happened infrequently of late years, but it is a possibility one easily avoided by the simple expedient of switching off.

If the car is to be left for half an hour or more, turn off the petrol cock. The formation of these habits of precaution—such as stopping one's engine before leaving it, shutting off the cock on the feed pipe, and draining the radiator before really long halts during frosty weather—will obviate lots of trouble. One would not dream of leaving a valuable horse unsecured and unrugged in the road—then why a car?

STEERING GEARING

The steering gear suffers more from stiffness due to bad lubrication than anything else.

Sometimes stiff steering can be cured by jacking up the front wheels, forcing or applying an ample supply of oil and grease and joggling the steering wheels. This cures a stiffness which arises from the pressure on the parts squeezing out the oil and grease, by relieving the parts of this pressure. The oil and grease enter freely, and on letting down the wheels steering is found all right.

The mechanism of the steering gear varies in design in different cars, but its essential features are shown in Fig. 184:

1, Steering column.
2, Steering box, half section.
3, Sector spindle.
4, Worm.
5, Lever operating throttle, worked from above steering wheel.
6, Lever operating steering rod.
7, Grease injector hole (closed by screw).
8, Thrust block.

Steering Column Details

Inside the steering box there is a skew gear of which the worm is carried by the axle of the hand wheel, and of which the sector is carried by the axle 3 of the lever 6. By means of the skew gearing the movement is made irreversible. That is to say, it is impossible to turn the hand wheel by deflecting the front road wheels.

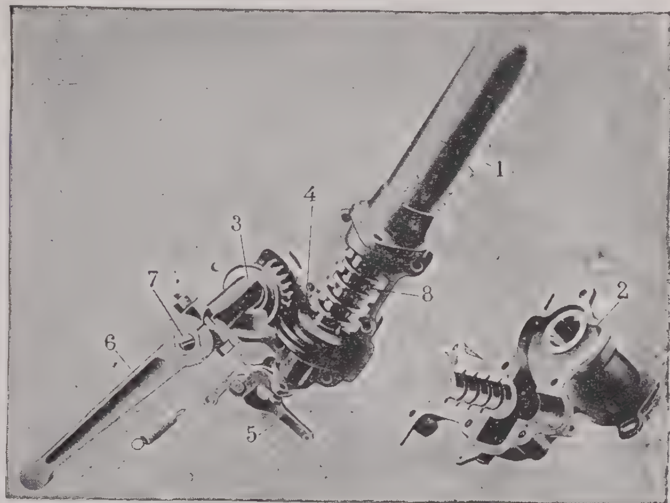


Fig. 184.—Steering Column Details.

The steering column (or pillar) is left hollow to afford passage to the throttle lever connection, which ascends or descends when the lever on the steering wheel is moved.

The overhaul and setting up of the mechanism of the steering gear requires a mechanical knowledge and skill beyond that of most chauffeurs. But the steering gears of to-day are practically free from wear for many years.

An accident may happen, of course, to the connecting rods and joints, disabling one or both front wheels from steering. In that case what may be done is difficult to say, but this sort of accident is happily very rare; it usually cannot be repaired on the road and the car has to be towed to the nearest mechanic or blacksmith's shop.

TOOLS AND APPLIANCES FOR CARE AND REPAIR OF CARS

The makers generally supply a set of tools for carrying on the car to be used on the journey or road, enclosed in a handy wooden box, except the tyre pump, which can be stowed away by itself.

They are as follows:

- Tyre pump.
- Grease pump.
- Hub cap spanner.
- Axle nut box spanner.
- Valve cap spanner.
- Large adjustable wrench.
- Small adjustable wrench.
- Carburettor jet key.
- Small oil can.
- Combination pliers.
- Screwdriver.
- Hammer.
- Small triangular file.
- Small chisel.
- Large chisel.
- Punch.

Other useful tools which should be carried are a smaller screw-driver, a centre punch, flat and half-round files, a set of tyre levers, a lifting jack, a tyre repair outfit, and a small hand vice.

In addition to the tools mentioned above, it is wise always to carry a well-chosen set of spares. The fortunate motorist will never require them, but they occupy very little space, weigh very little, and are inestimably valuable whenever they should be required. A good set of spares should include :

A set of sparking plugs.
A roll of insulating tape.
Several yards of high tension wire.
Set of carbons for magneto.
One valve, complete with spring, washer, and cotter.
Copper and asbestos washers (for sparking plugs, valve caps, cylinder plugs, etc.).
Taper pins.
Split pins.
Rubber union for water circulation.
Complete tyre, or a spare rim or wheel with tyre.
One or two inner tubes.
Hanks of copper, brass, and iron wire.
Sheet of fine emery cloth.
Squirt can of paraffin.
Six inches of lamp wick.
Box of wind vestas or storm matches.

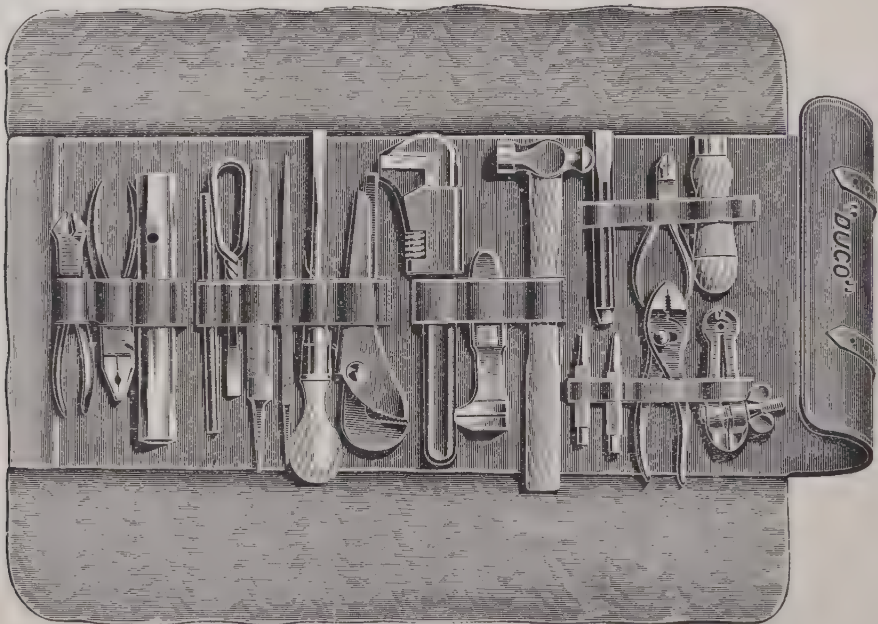


Fig. 185.—Tool Kit for Road Repairs.

A tool kit in a leather roll is shown in Fig. 185, with nineteen of the most necessary tools of good quality. This takes up less space than a box and is silent, and when unrolled the tools are get-at-able and seen at once in their place.

Tools for Motor Car Repairs

The hand tools for the motor house may be kept handily on a rack as shown in Fig. 186, placed on or over the vice bench. These tools must be kept clean and in good condition to be ready at any moment for efficient use.

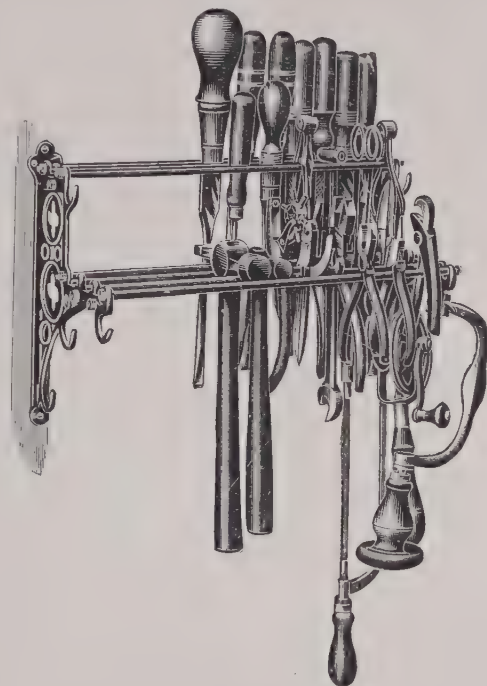


Fig. 186.—Tool Rack for Garages.

A soft soldering kit is of great utility both for use on the road and in the motor house. Soft soldering when well done makes many good repairs, stops leaks, and can be carried out anywhere quickly.

Soldering by soft solder looks an easy job, but it requires some skill only to be acquired by practice.

The surface to which the solder is to be applied must be thoroughly cleaned by filing, scraping, or by emery paper.

A good flux must be used, preferably with no acid. There are several fluxes sold in tins, all of them very good, such as "Tinol" and "Fluxite."

The soldering bit should be of a weight proportional to the masses of metal to be united or covered by the solder, a $\frac{1}{2}$ lb. bit and a 2 lb. bit will be found most useful. Bits are made, as shown in Fig. 187, with movable handles so that different sized and shaped bits may be screwed on.

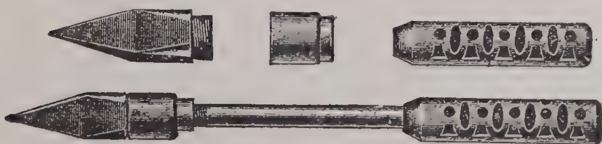


Fig. 187

A small Tinol set, consisting of a blow lamp and a small bit, shown in Fig. 188, is very useful on the road for small repairs.

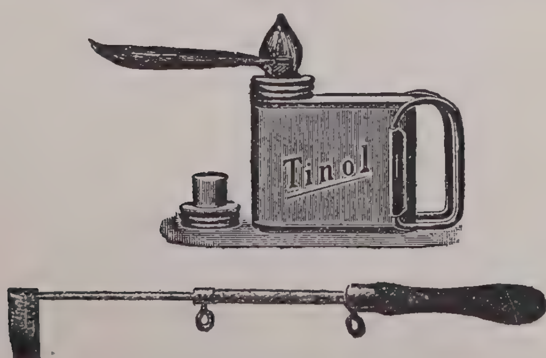


Fig. 188.—Soldering Kit.

For heavier work and for the motor house, a larger blow lamp and heavier bit is more useful, as shown in Fig. 189.

The nozzle of the bits must be "tinned." This is done easily by heating the bit to a very dull red

heat. Have a piece of common tinned iron—the end or lid of a meat tin or sardine box will do, if clean; put a small piece of soft solder on this tinned iron with some flux. Clean the nose of the hot bit as rapidly as possible with a rough file, then dab it on to the piece of solder on the tin and rub the nose well over the surface of the tin and through the melted solder; by this means the nose of the bit is tinned.

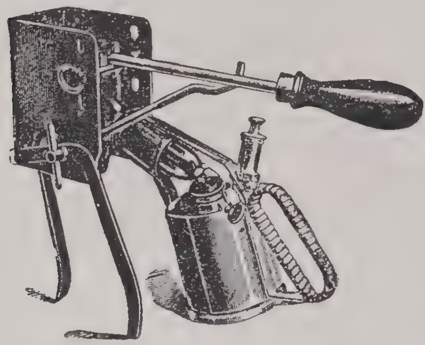
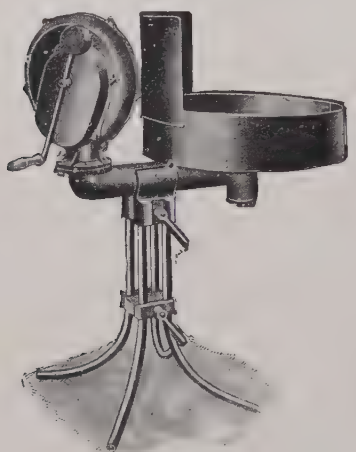


Fig. 189.—Blow Lamp for Soldering.

Not a bad plan is to use a lump of hard sandstone, hollow out a gutter in one face, in which the nose of the bit can be rubbed to and fro to clean it without filing. It can in this way be cleaned and tinned at the same time by placing a lump of flux and solder in the gutter. The sandstone will absorb some of the flux and always be ready to clean and tin the bit, and every time the bit is taken from the flame or fire it should be given a rub on the piece of tinned iron or on this sandstone.

The bit must never be made more than a very dull red heat, seen only in the dark. If raised to a bright red heat the copper scales off and the tin on the nose is oxidised hard.

Sweating in solder requires large bits and plenty of heat. Half bushes



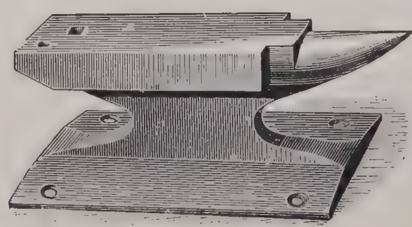


Fig. 190. Garage Forge and Anvil. Fig. 191.

may be united for boring by tinning the edges with a hot bit, the bushes being also heated to the melting point of the solder.

All petrol pipes, joints, and taps and unions should be sweated in with soft solder, the parts being tinned first by the bit.

A small forge is very useful in the motor house to use coal or coke

for heating larger articles. The one shown in Fig. 190 is handy and takes up little space. It is blown by a hand geared fan. It can be taken apart in a few minutes and stowed away. And a small anvil will be required like Fig. 191. These are useful for heating rods and couplings and many parts which require bending or straightening, for detempering steel, or retempering parts and odd jobs which a blacksmith would do on a small scale.

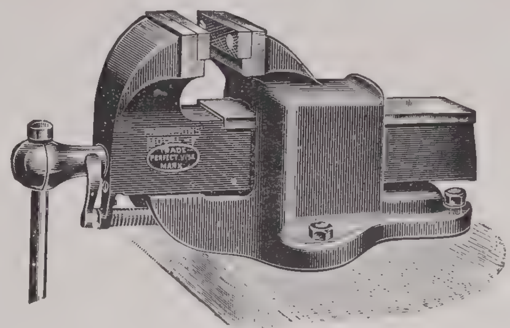


Fig. 192.—Parallel Vice, Quick Opening.

One or two vices are necessary. The parallel jawed Parkinson's vice is most useful. It has a quick release trigger, seen in Fig. 192, whereby the screw can be released and the movable jaw pulled out or pushed in without using the screw. The screw is used only to tighten up the grip. It is heavy and of cast iron with steel jaws.

Another type of useful vice is one made all of mild steel or wrought iron with steel jaws, shown in Fig. 193. It is much used in Government dockyards.

Vices should have copper and also lead protectors to fit over the jaws when gripping any article with a polished surface in order to prevent defacing or marking by the jaws.

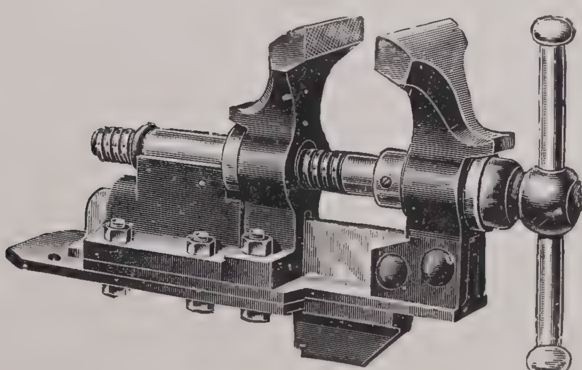


Fig. 193.—Forged Steel Vice.

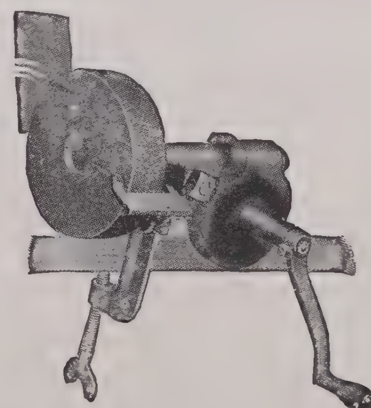


Fig. 194.—Tool Grinder.

A bench tool grinder is necessary in a motor house, preferably a high speed emery or carborundum wheel such as is shown in Fig. 194.

This machine is built for hard service. The body of the grinder is adjustable so that the wheel can be run either in the vertical or horizontal position. The cut worm gears are entirely enclosed. Ball bear-

ings are used to make this machine quiet and easy running, and it is fitted with an adjustable tool rest, scissor and chisel grinding guide.

Each machine is equipped with a carborundum wheel of medium

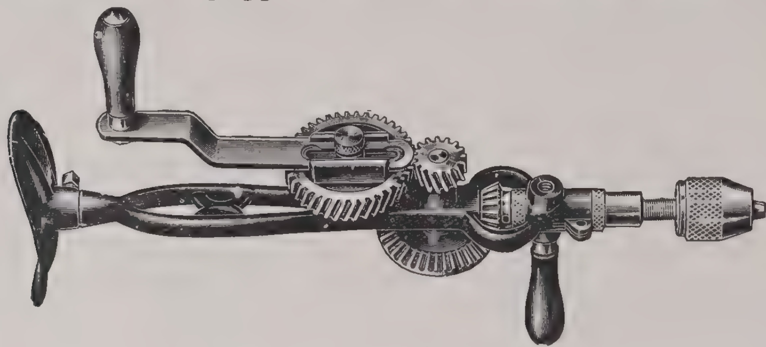


Fig. 195.—Geared Breast Drill.

grit faced with a very fine grit so that grinding and finishing can be done with the same wheel. The wheel is 5 inches diameter and $1\frac{1}{2}$ inch thick.

A high speed breast drill and bench drill are also necessary, together with a set of twist drills and taps. The drills should be chosen in two sets, one set to bore holes to be tapped, and the other set to bore holes to clear the screws, a set from $\frac{1}{16}$ in. tapping up to $\frac{1}{2}$ inch clearing should be kept.

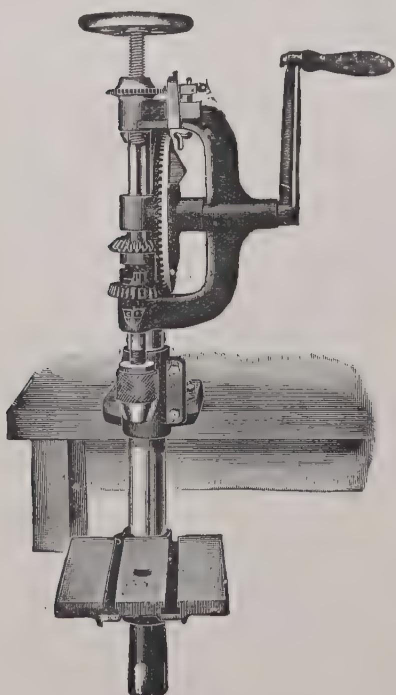


Fig. 196.—Vertical Drill.

A high speed breast drill is shown in Fig. 195. It has gear 7 : 1, giving a speed of up to 1,000 revolutions per minute. It has a main gear of skew wheels with double ball bearings and drills up to $\frac{1}{2}$ inch.

The bench drill with drill chuck is shown in Fig. 196. It has both hand and automatic feed.

These tools are chosen for an ordinary motor house without motive power, and will enable most repairs a chauffeur can do to be undertaken.

A lathe is a great acquisition in the hands of a man who can use it properly A common plain hand turning lathe will be sufficient for a man who is not well versed in turning, but if the man can use a screw cutting lathe such a lathe should be installed.

The present writer has had much experience of the lathe, $4\frac{1}{2}$ inch centre taking 25 inches between centres (see Fig. 197). A lathe is not of

much use without chucks. It should have a three-jawed self-centring chuck with two sets of jaws. Also a four-jawed (independent) chuck and a set of tools for iron turning, a set for brass turning, and a set for wood turning.

The Drummond lathe is also a good one for the motor house tool shop. Fairly heavy and accurate work of greater variety can be tackled

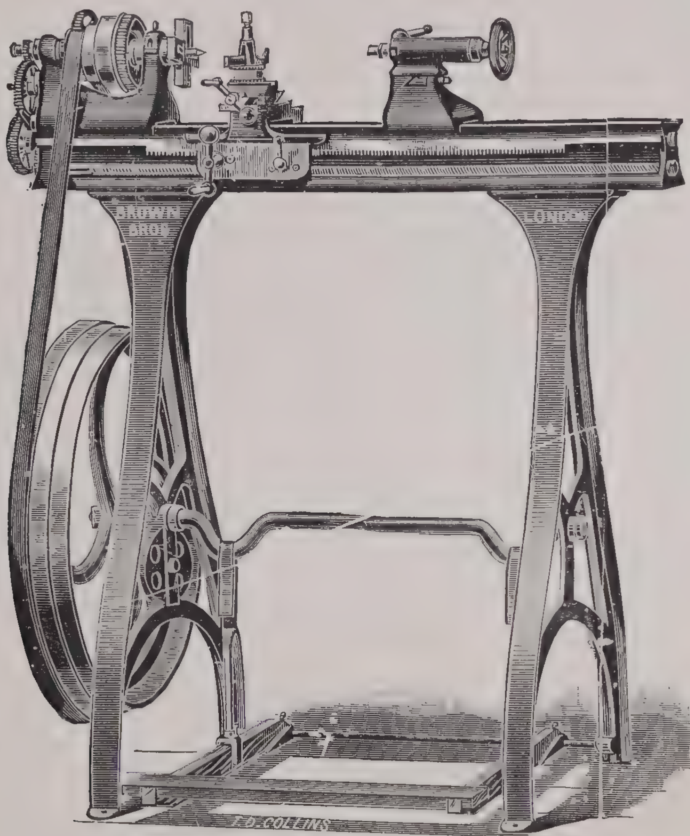


Fig. 197.—Screw Cutting Foot Lathe.

with this lathe, but it requires some skill as a turner to work it (see Fig. 198).

A couple of good screw jacks are necessary for lifting one end of a car completely. Fig. 199 shows a compound jack. In raising, the handle is used as a lever, and the operator is enabled to apply his strength to the best advantage. The lowering is accomplished by means of a double worm, which works very quickly, and requires but the smallest effort to turn it. The large size of the base renders this jack eminently suitable for changing detachable wheels.

Another useful type of jack is shown in Fig. 200. The lift can be

rapidly raised and lowered by the ratchet and rack, and the weight lifted by a worm and worm wheel. In the figure it is shown raising the ram into contact with wheel pivot bracket, after which the lifting will be carried out by the worm wheel and worm.

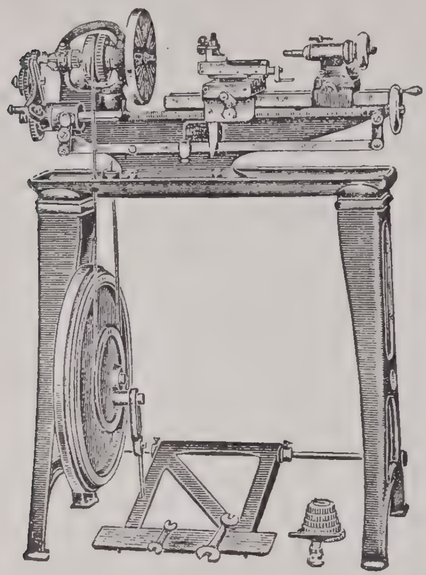


Fig. 198.—Drummond Lathe.

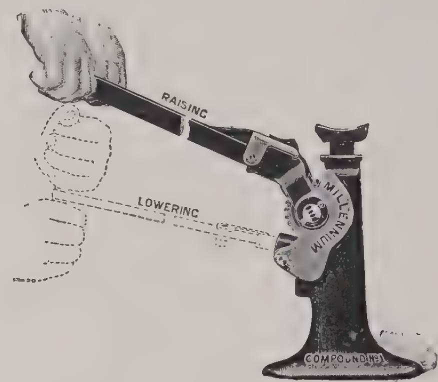


Fig. 199.—Screw Jack.

Other small tools and appliances will be necessary according to the necessity of the situation. A motor house in a town where mechanical aid can be found round the corner need have but few tools, while a motor house in the country where assistance cannot be readily got will need a full equipment.

Fig. 200.—Screw Jack.

CHAPTER V

OVERHAULING AND TUNING UP A CAR

Overhauling a Car.—This means dismantling the whole affair; removing the body, opening up the engine, gear boxes, and all enclosed parts, for examination and repair. It is work for the trained motor engineer and mechanic only. They alone can recognise wear and tear, can adjust and repair and correct all the component parts.

A complete overhaul need not be made on any well kept car oftener than every three to five years, so that the expense spread over that period is not so very great, even if sent to the works for the purpose. As it is only a job for experts, we need not here go into its details.

A thorough overhaul makes a car as good as new, and when it is in hand that is the time to put in new and improved component parts such as an improved carburettor, dual ignition, electric lighting, better silencer, improved lubrication, and so on, so as to bring the car up-to-date.

Tuning up a Car.—Just where to draw the line between overhauling a car and tuning up a car some writers on the subject are not very definite. Tuning up we take to mean adjusting the active component parts so that they give their best results and highest efficiency. And *before* any attempt at tuning up is made there must be certain assurance that the car in all its component parts is in the best of condition and repair.

It is useless to try to tune up a car with a poorly designed carburettor out of order, or with an engine with a cracked cylinder or worn out piston rings, and loose bearings.

A perfectly new car requires tuning up very carefully, and, as a rule, this is done at the factory before delivery. Sometimes, however, it is not very thoroughly done, and improvements can be made by resetting the magneto, the carburettor, the compression, and sometimes, but only rarely, the gearing from the engine to the road wheels.

In course of time all cars deteriorate and are surpassed in performance by newer cars with improved parts. Such cars when of good make are well worth overhauling, and replacing obsolete parts with newer and more up-to-date parts, and then finally well tuning up.

A writer tells of a new car on a racing track which when first tried made only sixty-two miles per hour, whereas eighty was expected. By

patiently tuning it up, principally by readjusting the carburettor and the magneto timing, it finally attained seventy-eight miles per hour.

In setting out to tune up a car the compression should be seen to. Only by a gauge for pressure can the compression in the cylinders be shown. For ordinary petrol 80 lb. is about correct; more is apt to cause pre-ignition, and less means loss of power. For use with benzol a higher compression may be used.

A pressure gauge with a non-return valve and a releasing tap may be used to indicate the compression; it screws into the spark plug hole. One cylinder at a time is tested, the others having the ignition plugs all out. In making the test the engine must be cranked round two or three turns rapidly.

The compressed air enters the gauge at its full pressure, which is registered by the pointer. The air cannot return through the valve, but it may be released by a tap, when the pointer will return to zero. This kind of pressure gauge may have some errors due to inertia, but it gives a fairly reliable indication. Another kind of indicator is shown in Fig. 201.

Fig. 201.—Compression Indicator.

This indicator is free from inertia and consists of a small cylinder provided with a steel piston, which is forced upwards by the pressure of the gas in the engine cylinder. This upward pressure is counteracted by an adjustable coiled spring pressing downwards on the piston. When the spring is insufficiently compressed, the steel piston is lifted a limited amount by the pulsating pressure in the engine cylinder; but when correct adjustment is obtained, it just ceases to move under the momentary maximum pressure occurring at the end of each compression or explosion stroke. It is suitable for all kinds of internal combustion engines, and records compression pressure readings at any engine speed. By its judicious use it is possible to keep the engine accurately tuned up, and to get the benefits of the maximum power developed.

If the compression is not satisfactory, there may be leakages at the spring rings, valves, spark plugs, and other places, and an overhaul must be made to cure these faults. If the compression is equal in all cylinders, but too low, the combustion space can be reduced in capacity by some means—for instance, by fastening a thin disc on top of the piston, or on the valve cap faces inside; and thus we tune up the cylinder and piston for compression.

The next thing to be tested and tuned up is the carburation. Many cars, even when new, are not fitted with the best carburettor. But tuning up does not include reconstruction; it means making the best of the car as it stands.

In most carburettors the petrol jet and air inlets are adjustable or

replaceable; several different sized petrol jets should be tried and the results noted. Then the admission of more or less air should be experimented with. The addition of an extra air valve which admitted air at the higher speeds gave a great increase of power in one case known to the present writer in a car fitted with what is considered a very good carburettor.

Carburation fails as a rule by the air being deficient at high speeds of the engine and to bad design of the carburettor and its pipes.

The later types of automatic carburettors can be more readily

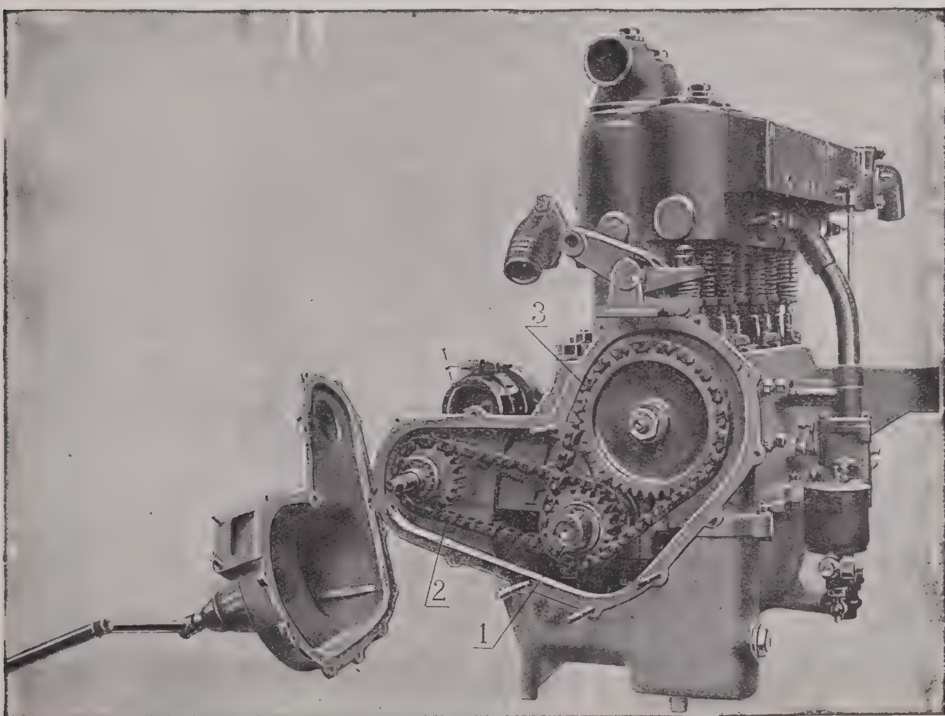


Fig. 202.—Valve Gearing Chain.

tuned up than the older ones, both the air and petrol jets being adjustable readily. It is worthy of note that sometimes an engine can be much improved by refitting a new carburettor of larger size with larger induction pipes. One of the most common faults in the carburation system is this. The whole arrangements are too small, a $1\frac{1}{2}$ inch pipe and carburettor where a 2 inch pipe and carburettor ought to be. If the carburettor and its connections are too small, we must be content to make the best of them without attaining a high degree of efficiency.

Timing the Valves.—First see that the tappets which strike the end of the valve rods or stem, to lift the valves, are screwed up or set so that only the smallest amount of space is apparent between them: $\frac{1}{50}$th

inch is ample; when the valve is hot, and the stem expanded, it may be less.

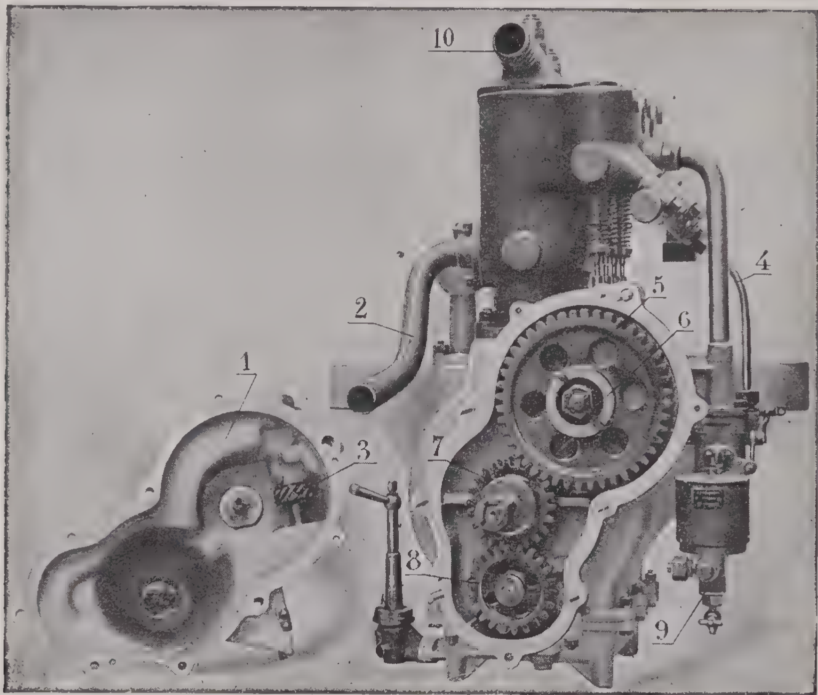


Fig. 203.—Valve Gearing Fly Wheels.

It is to be remembered that grinding in a valve lowers the end of the stem, and it may touch the tappet; hence the tappet must be adjusted after grinding.

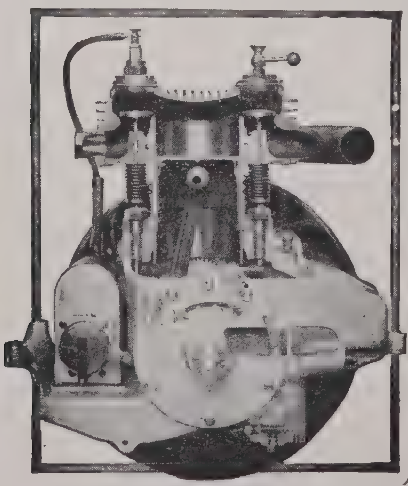


Fig. 204.—Inlet and Exhaust, Opposite Sides.

In tuning the engine we first attack the inlet and exhaust valves.

In some engines the valves, inlet and exhaust, are driven from one shaft, geared two to one, as shown in Fig. 202 with chain gear, and in Fig. 203 by toothed gear. In these engines the exhaust and the inlet valves are operated by one cam shaft, and as the cams are not movable on the shaft it is impossible to adjust the inlet valve without altering the exhaust timing and vice versa.

When the exhaust valve is on the opposite side to that of the inlet valve as in Fig. 204 we can adjust the inlet and exhaust timing separately.

The Lanchester engine is one of this kind. In Figs. 205 and 206, the compression beginning and ending is shown, also the firing point and

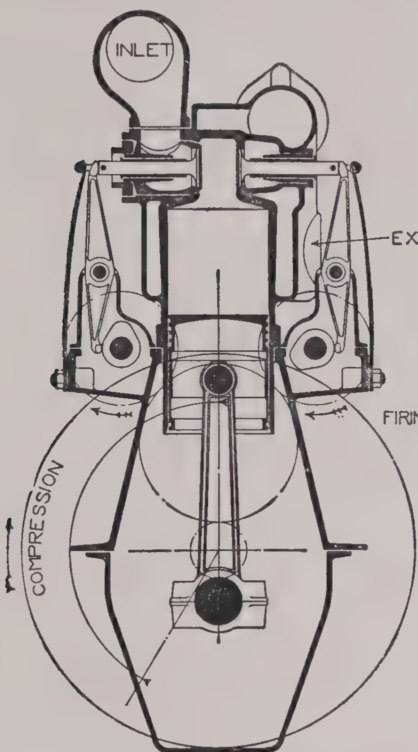


Fig. 205.—Inlet and Exhaust, Opposite Sides.

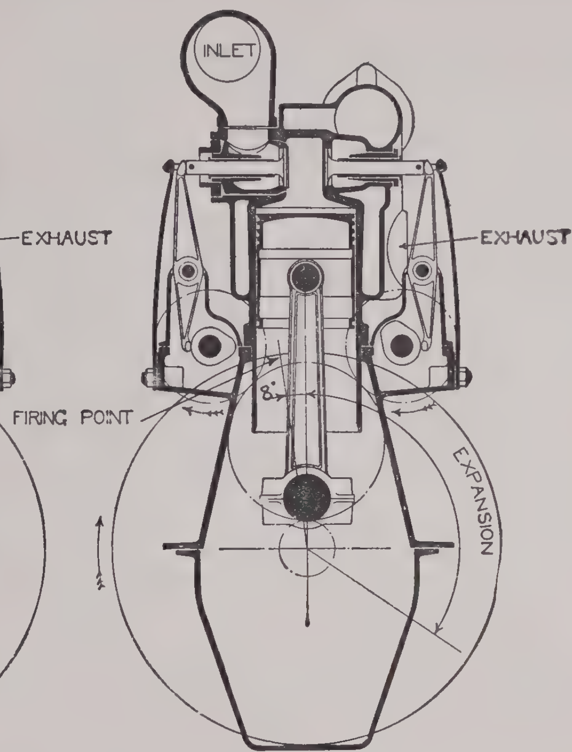


Fig. 206.

opening of the exhaust. In diagram Fig. 207 the exhaust cycle is given, opening about 45° before end of working stroke and closing about 8° beyond the top centre when suction begins.

In diagram Fig. 208 the inlet curve is shown, opening about 8 to 10°

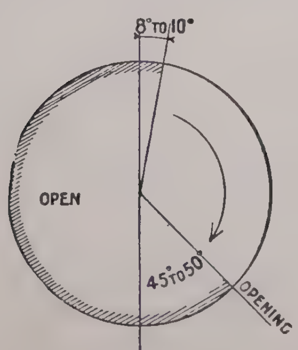


Fig. 207.

Diagrams showing Valve Timing.

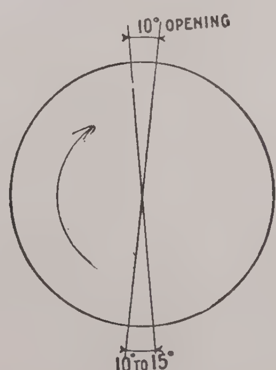


Fig. 208.

after the end of the exhaust stroke and closing 10 to 15° after end of the suction stroke. In Fig. 209 we have the correct timing diagram for the four strokes. The outer curve shows the inlet valve opening considerably beyond the dead centre line on which the crank pin stands 17° in this case, while the exhaust is open up to 22°, at which angle the inlet closes. After passing the lower centre, the exhaust is shown here opening at 52° from the lower centre.

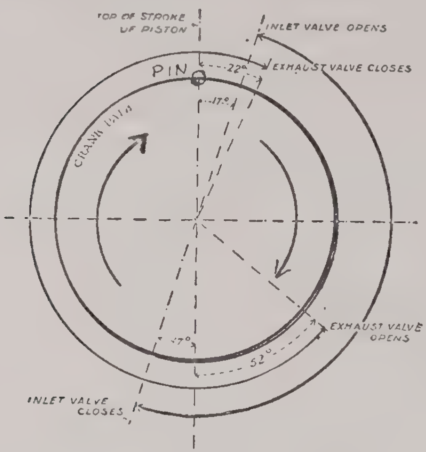


Fig. 209.—Valve Timing Diagram.

In Fig. 210 the piston and connecting rods are shown in their relative positions on the suction and exhaust strokes.

A, Valve opens after completion of exhaust stroke (approx. 0·06 inch for $5\frac{1}{8}$ inch stroke).

B, Valve closes after completion of suction stroke (approx. 0·11 inch for $5\frac{1}{8}$ inch stroke).

C, Valve closes after completion of exhaust stroke (approx. 0·02 inch for $5\frac{1}{8}$ inch stroke).

D, Valve opens before completion of working stroke (approx. 0·42 inch for $5\frac{1}{8}$ inch stroke).

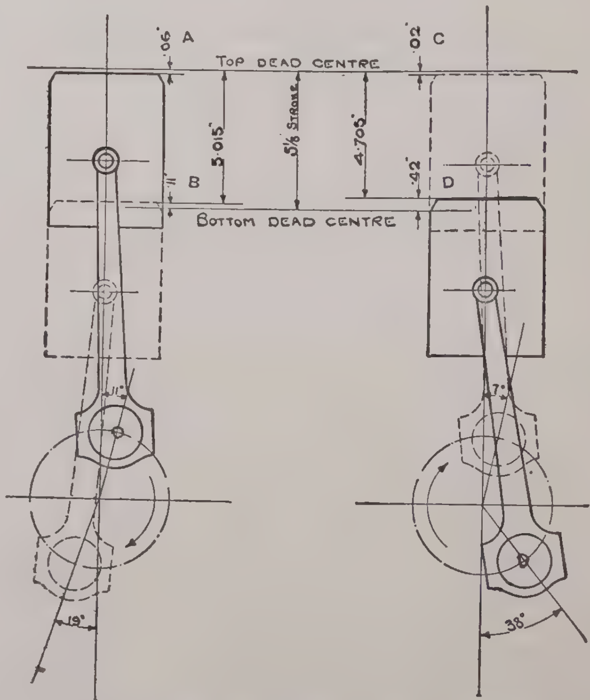


Fig. 210.—Valve and Piston Timing Diagrams.

All these angles are greater than those shown in Figs. 207 and 208 because this diagram is for an engine of much higher speeds. Correctly we should have the valves timed for the different engine speeds, but as the valves are positively opened and shut by cams on a rigidly geared shaft this is difficult to do—in fact, impossible without a complicated construction. We must time the valves for one speed only, and that speed about the average, or the one most in use.

In timing the valves it will be noted that with toothed wheel gearing, Fig. 203, the cam shaft turns in the opposite direction to the main shaft, while with chain gearing, Fig. 202, both shafts turn in the same direction.

In order to time the valves with the wheel gearing; the wheels are disengaged and meshed either a tooth ahead or behind, so as to open and shut earlier or later as desired. It will be seen that if we advance the inlet time we simultaneously retard the exhaust time if both are on one side of the engine. But if the valves are on opposite sides we can time the inlet independently of the exhaust valves.

In the former case we can only time the valves to the best when one needs advancing and the other retarding or vice versa.

The flywheel is generally marked on the diameter coinciding with the crank pins and sometimes the positions also of the inlet and exhaust openings, so as to facilitate timing.

With engines of to-day it will very seldom be found possible to improve the valve timing which has been made at the factory, and all that can be done is to make them gastight, and set the tappets correctly.

Timing the Magneto.—An ignition advance lever is connected with the commutator which enables the driver to vary its position and thus advance or retard the time of the ignition in the cylinders. It should be explained that when the engine is running fast it is necessary to cause the spark to occur slightly before the pistons are at their full height, so allowing for the small, but (having regard to the speed of the engine) appreciable time it takes for the ignition to take full effect. Whilst travelling at full speed the ignition lever should therefore be fully advanced, to keep up the speed; but when starting, or if the car is travelling slowly, the lever should be retarded to prevent ignition occurring before the pistons reach the top of their stroke.

In the magnetos the make and break shown in Fig. 211 can be retarded thus. The outer cover carrying the terminal 24 has an arm 116 to which the ignition advance lever is connected. The cover has two cams, 21—21, which cause the breaks to occur at the correct time. The outer ring or cover can be rotated right or left by the lever 116, and so causes the cams to lift the contacts 5—6 sooner or later to advance or retard the spark. This rotation can be carried through 20 to 30°.

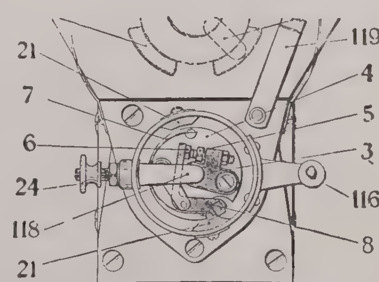


Fig. 211.—Timing Magneto.

The driving shaft of the magneto is geared either by chain or toothed wheels; the chains or wheels must mesh together so that when the piston is at the firing position at slow speed the armature of the magneto should be in the position shown in

Fig. 212—that is, the position of maximum current. As the speed increases, this position at which break occurs is advanced, so that the break occurs at the higher speeds at a position of the armature where the current is below the maximum.

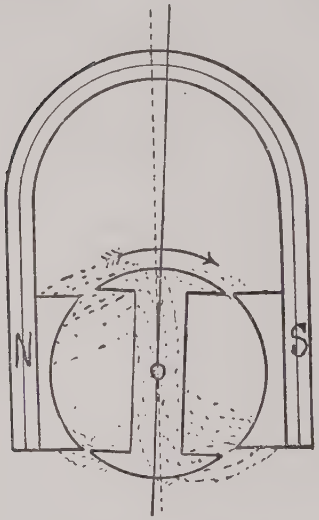


Fig. 212.—Timing Magneto.

This, however, is compensated for by the higher speed of the magneto drive.

To time the magneto, we first presume that the magnets are up to their normal power. If they are not, the spark will be weak at all speeds, and they must be remagnetised—a job for an electrician or man skilled in magnetos, with the necessary apparatus.

It would hardly pay for an owner to set up a magnetising plant in order to magnetise his magneto once in a year or two.

The spark contacts 5—6 should be adjusted as before described. It might be possible to improve the ignition by shifting the driving gear one tooth back or one tooth ahead. There are cases where this tuning has proved a considerable improvement.

On the gear wheels there is a tooth of one wheel marked to go in between two marked teeth on the other wheel, so that in replacing the magneto, if it has been moved, it can be correctly meshed again.

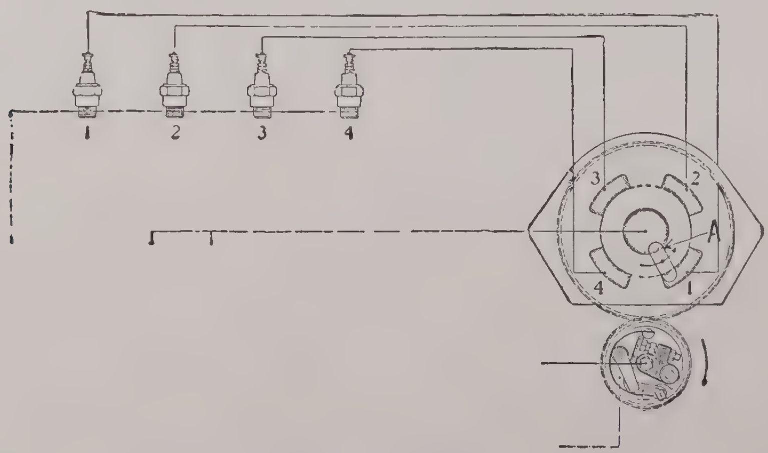
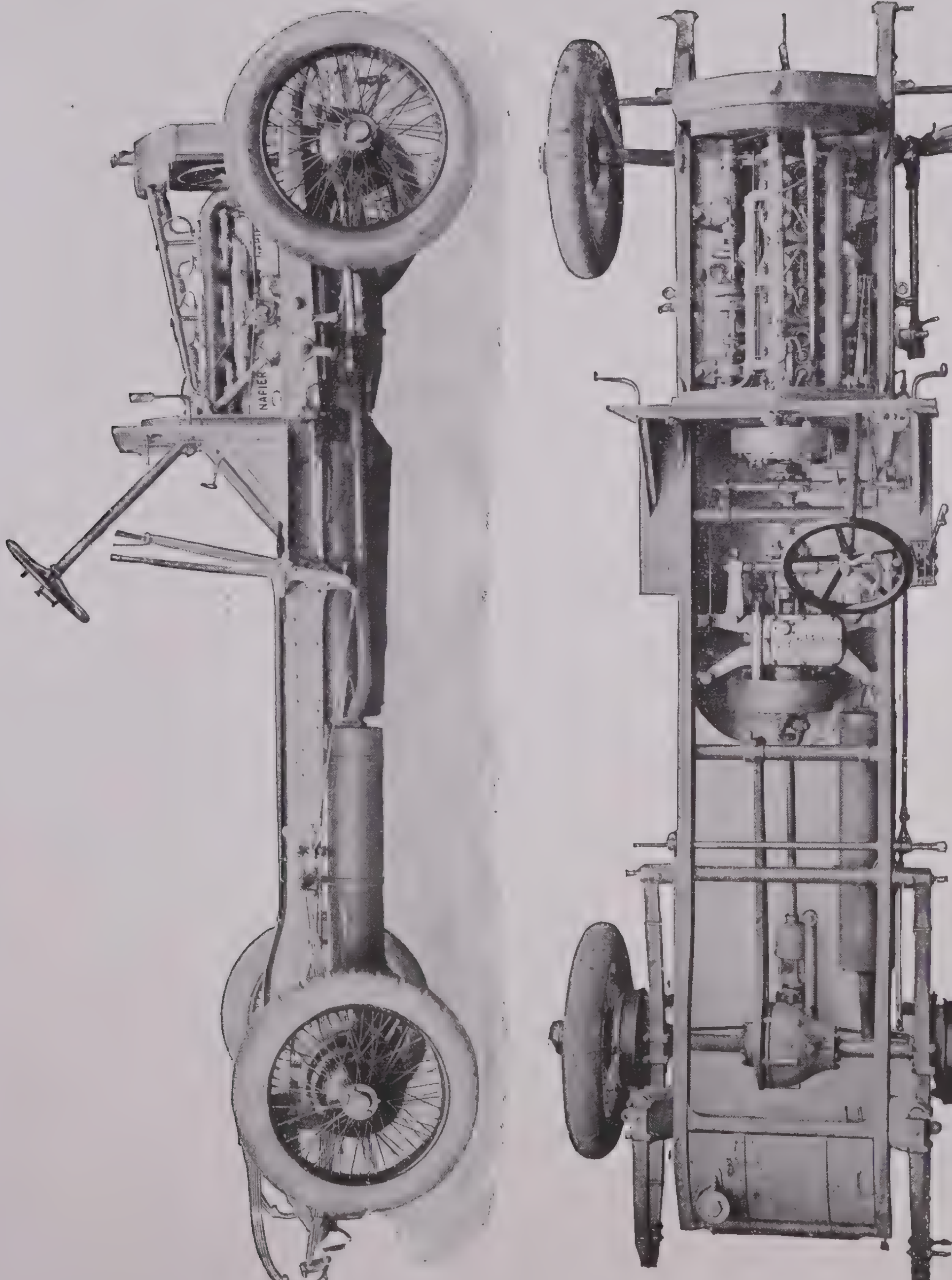


Fig. 213.—Timing the Distributor on Magneto.

But in replacing it, care must be taken to see that the rotating arm A in Fig. 213 in the distributor is on the correct segment, 1, 2, 3, or 4. The magneto armature on a four-cylinder engine runs at same speed as the engine, but the distributor runs at half speed. Hence if when



PLAN AND SIDE ELEVATION OF NAPIER CHASSIS, SHOWING SIDE FRAMES, SPRINGING, AND ENGINE SUSPENSION.

the magneto is removed the arm A is on contact 1, for instance, and the armature is turned round exactly one turn, its gear wheel would be in the same position for meshing, but the contact arm A would be now on contact 3 exactly opposite to its correct position.

The rule when replacing the magneto is to find out which cylinder is in firing position or set one in firing position. Turn the magneto till the distributing arm is on the corresponding contact piece, then mesh the gear wheels so that the teeth marking corresponds.

GEAR RATIO BETWEEN ENGINE AND ROAD WHEELS

Having tuned up a car by ensuring good ignition, carburation, and compression, and tuned the valves all up to concert pitch, the power of the engine will be at its maximum, and it would, without going at greater speed itself, be capable of driving the car faster if the gear ratio were altered to a higher gear, or it might take hills at a higher speed. To alter the gear ratio with a chain driven drive is easy enough by fitting larger chain wheels, but on a back axle bevel or worm drive it means reconstruction at the factory, and that is too costly to be undertaken for an experiment. The only thing to be done in this way is to put in larger road wheels or larger tyres. But instead of a gain in speed obtained by tuning up, we may gain by saving fuel, and an easier running engine, more silent and requiring less repair or attention.

CHAPTER VI

DRIVING THE CAR

THE driving of a car is no longer invested with the wonder surrounding it a few years ago, the growth of automobilism having daily made more and more clear the fact that any ablebodied person, anybody whose eyesight is normal, anybody who has control of his or her hands and feet, may learn to drive a car.

There is no royal road to expert driving, but the essentials of the art are so few and so simple that anybody who cannot learn to drive a car certainly cannot learn to drive a horse.

Prior to starting out, the driver should—

(1) See that the crank case contains the proper quantity of oil, namely, 5 litres (or $8\frac{3}{4}$ pints) in the case of the four-cylindered 25 h.p. model, and $3\frac{1}{2}$ litres (or $6\frac{1}{8}$ pints) in that of the 26 h.p. eight-cylindered chassis. This he can do by examining the oil-level gauge rod, which is marked with minimum and maximum depths. The oil level must on no account be permitted to get below the minimum depth, and for it to exceed the maximum mark is to invite excessive lubrication, engine sooting, leakage and waste. Too much oil will do very little real damage, but cause considerable trouble. Too little oil will do both.

(2) See that the gear box and differential casing are filled with oil to the depth marked on the gauge rods, or that of the overflow plugs fitted to them, closed (when not in use) by thumb screws.

(3) See that all other parts of the car are properly lubricated. It is not suggested that one need make a complete round of every grease cup and oil hole every time the car goes out, but in writing we are assuming that the car has just been delivered new. If the crank case, gear box, differential casing, grease injector holes, grease cups, lubricators, and oil holes are adequately filled they may be left so. Experience is the best instructor as to the frequency with which the lubrication must be repeated.

During the first few weeks the driver will be well advised to make regularly a complete inspection of all lubrication points, to familiarise himself with them and to identify those which require the more frequent attention and those which only call for periodical replenishment.

(4) See that the petrol tank is full. This may be ascertained by unscrewing the filler cap and inserting a clean wooden stick or ruler

after the gauze is removed, but the greatest care must be observed that no dust or other foreign matter is admitted to the tank.

(5) See that the radiator, water tank and water jackets are full. This may be verified by unscrewing the water filler cap on the radiator. If the cooling system is adequately filled the water level will be up to the foot of the gauze at the foot of the filler column or tube.

(6) See that all overflow and drain plugs and cocks are securely shut off.

(7) See that the petrol cock on the feed pipe (from tank to carburettor) is open.

(8) See that the gear lever is in the "O," neutral or out-of-gear position.

(9) See that the hand brake is "On," locking the rear wheels.

(10) See that the magneto switch on the dash is in the "Off" or "A" position. When "On" it will be at the "M" angle.

STARTING THE ENGINE

The foregoing details being found in order, if the engine has been standing cold for some time it is advisable to give the crank a few brisk turns before switching on the magneto.

This is better than flooding the carburettor, which will often tend to accentuate any starting difficulties that may have arisen. The effect of two or three sharp revolutions of the engine—calling for neither effort nor risk if the switch is left off—with the throttle open, is to set up a wholesome activity of the induction system.

After the preliminary swing,

(1) Move the magneto switch on the dash to the "M" or "On" position.

(2) Push in the spindle of the starting handle (on which it is mounted), turn it lightly and gently in a clockwise direction until its ratchet engages with the ratchet on the fore end of the crank shaft, and then—holding the handle (which should be at the lowest point of its circle) loosely in the crooked palm, keeping the thumb on the same side of the handle as the fingers—give the handle one or two sharp turns. In 90 per cent. of cases the engine will fire on the first upward pull of the handle. In the remaining 10 per cent. of cases it will do so on the second.

Now step to the side of the steering wheel and gently ease back the throttle lever until the engine settles down to a nice running speed. Great harm eventually results from "racing" the engine—that is, allowing it to run at excessive speed—when it is not doing useful work, and there is nothing more offensive to the real motorist than to hear a stationary car's engine running at twice its minimum turnover speed.

STARTING THE CAR

On getting into the driving seat, depress both pedals to the full extent, and take off the hub brakes by drawing back the brake lever released for motion by pressure on the trigger at the top), as far as it will come.

The right pedal performs two duties. The earlier portion of its movement throttles the engine—by decreasing the amount of explosive mixture delivered to the inlet valves—to its minimum running speed. Further depression of the right pedal applies the foot brake, by expanding the brake shoes into frictional contact with the inner peripheral surfaces of a hollow drum mounted on the rear end of the secondary gear shaft.

The left pedal disengages the clutch, so that its depression severs flywheel and transmission gear.

With both pedals firmly depressed, move the lever on the steering wheel clockwise, to open the throttle. Still keeping the feet on both pedals, rest the palm of the right hand on the head of the change speed lever, and move it from the neutral or " out of gear " position into the first-speed position, which is, roughly, one-third of the quadrant to the rearward of the neutral position (the second and third-speed positions lying still farther back, and the reverse position being at the extreme forward end of the quadrant). The engagement of the gear will be certified by a light " locking " sensation communicated to the hand of the driver, difficult to describe, but always intuitively recognised, just as one recognises when a door lock tongue turns or a gate latch bolt shoots home, though unable to see lock or bolt.

Now, the first-speed gears being meshed, and the engine running well, lift up the right pedal very gradually.

Just as it is about three-quarters of the way up, allow the left pedal also to rise gradually. The clutch will now take up the load, communicate the motion of the crank shaft (through the gear box, propeller shaft, differential, and live rear axle) to the road wheels, and the car will move forward on its first speed.

CHANGING GEARS

The condition of the road being favourable, and more rapid progress being desired, depress both pedals, the left one completely, and the right one slightly, to throttle the engine and disengage the clutch, draw the change speed lever back into the second-speed position, and again allow the clutch to engage, releasing the decelerator pedal just before the clutch takes up the drive.

To get into third speed, repeat the process, bringing the lever through

the gap into the inner section of the "gate," and pushing it forward into the third-speed position, which is at the fore end of the inner (or left hand side) slot of the gate.

To engage the fourth speed, repeat the declutching process and draw the lever right back to the rear end of the inner side of the gate.

Gear changing is an art. There is nothing in it, given good change speed mechanism, but before one can change speed with real noiselessness one has to learn to gauge pinion speeds.

The pinion speed having been gauged, and the clutch being thoroughly out, the change speed lever cannot be moved too quickly; but recommendation of a quick, deft movement does not imply crash, bang-it-in, hit-or-miss changes.

If one suddenly brings the teeth of the second-speed pinion on the secondary shaft (which is revolving at a certain speed) into contact with those of the second-speed pinion on the more slowly moving intermediate shaft, a most offensive grating sound will be produced. One has to find by experience just at about what flywheel speed one can change to higher or lower speeds. This knack can be mastered in a few days. It repays a little study and patience.

Before engaging the reverse speed the road wheels and the gear shafts must be absolutely stationary. The engine should be throttled down approximately to the revolutions per minute at which the first gear was engaged.

A whole book might be written upon gear changing without redundancy, but an hour's practice in some quiet lane or fairly level open space will do more to teach the art of certain, easy, and silent changing than can the most explicit and lucid of written instruction.

Although it is wrong both in theory and practice to run the car slowly on a high gear, and to climb hills—or attempt to climb them—on a gear higher than that at which the engine will do the work without undue stress, the change speed mechanism should not be employed to make every little speed variation which may become necessary owing to the exigencies of traffic, and the driver should bear in mind the fact that the third speed, which is a direct drive from flywheel to differential, is the most economical of power.

The use of the throttle lever on the steering wheel and the decelerator pedal (on the right of the steering column), in conjunction with a discreet amount of clutch manipulation, will be found to give a surprisingly wide range of speeds on any gear that may happen to be in use. As an example, by use of the throttle alone, the pace of the car can be made to vary from 10 to 30 miles per hour on the direct driven third speed, without clutch manipulation.

The foregoing instructions refer to the De Dion cars. They, however, are generally applicable to all motor cars.

The following "Don'ts" for novices issued by the De Dion Company for the benefit of drivers are somewhat humorous and sarcastic, but are

nevertheless golden rules. Their brevity and caustic sarcasm make them all the more easily remembered.

There is nothing more to be said concerning the driving of the De Dion Bouton car which does not apply with equal force to the driving of any car. A few general hints, founded upon observation of all sorts and conditions of drivers, may be useful. The reader personally may neither appreciate nor need such hints—in which case he may pass them on to somebody who needs them.

Don't set out to do with the horn and brakes what should be done with the head and throttle.

Don't begrudge a good car a good supply of good oil and good grease—the water it also needs costs nothing, which fact levels up matters.

Don't look back after you pass the man on a car twice the size of yours. He may not like it, and there's generally something to watch ahead.

Don't go ahead when you can't see ahead. "Ahead" is the place where the collisions come from.

Don't drive fast round corners; it costs a lot of rubber. Slow down, or even lift out your clutch for a moment, save money, and avert possibility of a skid.

Don't let the clutch jump home. It will—any clutch will—but it shouldn't be allowed to do so.

Don't try all-out to wreck quadrant, change speed lever, and gear box every time you want another gear. You should act upon the *suaviter in modo* principle. The gear box itself does the *fortiter in re* part of the business.

Don't insist on your share of the road; anybody who doesn't give it to you instinctively is dangerous company—abreast, before, or behind.

Don't hug the delusion that an insurance policy is always as good as it reads. The number of new cars paid for by insurance companies can be estimated without a comptometer.

Don't wait to get into gaslight to consult your three-year-old lighting-up table; light up just before you see that it is time to light up.

Don't spend hours coining excuses for a tail lamp that blows out or shakes out. A decent tail lamp, costing a guinea, does its work.

Don't "just get between" two other vehicles—even when they are stationary. You save half a minute doing so. The record time for fitting, painting, and varnishing a new wing is nearly half a week.

SIDE SLIPS

In driving a car there is sometimes the phenomenon known as side slip. Side slip occurs mostly on going round corners at high speed, and is assisted by a slippery or greasy state of the road. In flying round a sharp curve the heavy car tends to continue in a straight line and is compelled to take the curve only by the steering front wheels and the frictional resistance between the tyres and the road. Centrifugal force

increases as the speed increases, and the frictional resistance decreases as the speed increases. Side slip is mostly due to high speed combined with a slippery surface at corners, but it occurs also on the straight road when there is much of a camber on the road and it is slippery at same time. If by any means the wheels, front or back, spin or skid—that is, rub round at the point of contact with the ground—the friction is very much reduced and the car will slide sideways into the gutter. If the brakes are applied suddenly or the clutch engaged quickly the wheels will skid and the back of the car swerve into the gutter. A big car on a greasy road will side slip merely by opening the throttle suddenly by the accelerator pedal.

Side slip occurs mostly at the rear wheels, but sometimes the front wheels also slide. The driver can do little in case of front wheels skidding but take bends easily, and non-skid tyres may be used. When the rear of the car slides to the left, the front will face to the right. The driver must first thing take out the clutch, and if the brake is on release it, turn the steering wheel to the left, and let the clutch in gently, when the car can pull straight on the road again.

Instinctively beginners are inclined to put on the brakes to stop a side slip, only to make the side slip worse. The stoppage of the slip depends on instantly taking out the clutch and releasing every brake.

A car should never be sharply steered from the side of the road into the centre of the road ; it will slide its rear into the gutter, whether it has been running along the roadside or starting from the roadside ; in approaching the crown of the road from the side it must be done gradually.

The whole lesson of side slip is that no sudden application of brakes, nor acceleration of speed, nor change of course, should be made. Gentle, easy motions and gradual applications of clutch and brakes are necessary if we are to avoid side slips.

Easy starting up of an engine should be learned by drivers. The proper way is to open the throttle wide and shut off the ignition. Give the engine a few turns with the crank, then turn on the ignition after shutting down the throttle to the point for slow running. If the engine does not start on switching on the ignition it will start off easily and quietly by one pull of the crank.

In driving generally the best will be got out of a car by driving with the ignition as far advanced as possible without engine knocking, and with as much air admitted to the carburettor as possible without missfiring, and attending to lubrication.

Sometimes on wet grass or other slippery roads the rear wheels will not bite at starting, but spin or skid, a good push being necessary to get a move on. It is more effective than pushing to pull on the front wheel spokes. The rear wheels should never be thus hand spoked, for immediately they spin round the person holding the spokes would be thrown violently down.

CHAPTER VII

ELECTRICAL CARS

These may be divided into two classes: the storage battery car and the petrol electric car.

In the first the electrical energy which turns the electromotor driving the car is carried in secondary batteries or "accumulators" which can store a sufficient quantity of electricity for runs varying from seven to twelve hours.

When they are exhausted the accumulators must be recharged from a dynamo electric machine driven by power.

For town work electricity has much to recommend it. It is very cleanly, no exhaust, no foul burning smoke from lubricating cylinder oils, with which the motor car and motor bus fill the streets of the towns, no noise, and under perfect control.

The principal parts of the vehicle are the battery of accumulators, the electric motor, the controller, and some speed reducing gearing between the motor and the live axle in order to reduce the motor speed to the speed of the wheels. A fairly high speed motor is desirable, something about 1,600 to 2,000 revolutions per minute. There is no advantage in low speed; while the high speed motor is equally efficient, it has less weight and bulk.

High efficiency at all speeds and loads is of first importance in an electric motor-car motor. Stored electricity is too expensive to be wasted in an inefficient motor, and the accumulator charge will last longer with the more efficient motor.

Hitherto the great drawbacks to electrical propulsion of vehicles have been the great weight and short life of accumulators on vehicles.

It has been proved over and over again that no accumulator with lead plates will succeed. They are too heavy and too fragile—fragile both mechanically and electrically—so that until some other more robust plate developed, electrical propulsion was not to be considered as practicable.

We have now the Edison cell with steel and nickel plates in steel boxes. These have proved robust and durable in action and bid fair at present to give the electrical vehicle a fair field of usefulness. More especially as nowadays there is, or at least ought to be, every facility for recharging or relaying the accumulators almost anywhere.

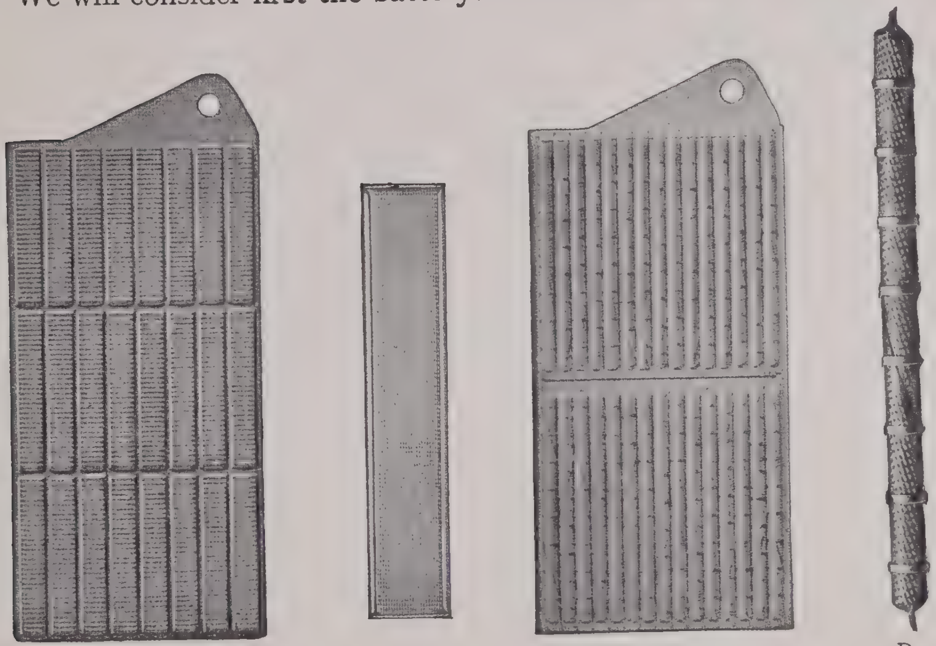
Then again, the old accumulators took a long time to charge. Rapid

charging spoiled them, and rapid discharging or overdischarging also ruined them; in fact, a long list of "Don'ts" and instructions was sent out with them, neglect of which meant battery failures.

The Edison cell can be rapidly charged and discharged, and completely exhausted without injury.

It will, therefore, not be necessary to consider the lead plate accumulator.

We will consider first the battery. The Edison battery has a further



A
Negative Plate.

B
Flat Pocket.

C
Positive Plate.

D
Positive Cylinder.

Fig. 214.

advantage in that the electrolyte or fluid solution in which the plates are immersed is an alkaline solution, which does not corrode the metals nor emit corrosive fumes.

The fundamental principle of the battery is the oxidation and reduction of metals in an electrolyte which does not dissolve and will not combine with either the metals or their oxides. Also an electrolyte which, notwithstanding its electrolysis by the action of the battery, is immediately reformed in equal quantity and is, therefore, a practically constant element without change in density or conductivity over long periods of time. Therefore, only a small quantity of such electrolyte is necessary, permitting a very close proximity of the plates, and rendering it unnecessary to take hydrometer readings until about nine or ten months after being put into service; this simply to determine when it is necessary to empty the old electrolyte out and put in new. The

active materials of the electrodes being insoluble in the electrolyte, no chemical deterioration takes place therefrom.

The electrolyte is 21 per cent. solution of potassium hydrate, plus a small amount of lithium hydrate. The active metals of the electrodes, oxidized and reduced in this solution, are nickel and iron. These are not put in as metals, but as nickel hydrate and iron oxide respectively.

Fig. 214 will give quite a clear idea of the construction of the Type A plates. The flat plate A is made up of a nickel plated steel grid, into the interstices of which are placed and hydraulically pressed the perforated corrugated steel pockets B, filled and packed previously with iron oxide, to which a small percentage of metallic mercury has been

Fig. 215.—Plates Nested.

Fig. 216.—Complete Cell.

added to increase the electrical conductivity. This forms a negative electrode.

The plate C is the positive electrode. It consists of a nickelled steel grid, on to which are secured perforated steel tubes D reinforced by equidistantly spaced steel seamless rings. These tubes are filled with alternate layers of nickel hydrate and very thin flake nickel, solidly and carefully packed by the loading machine. The nickel hydrate layers comprise the active material, while the metallic nickel acts as a conductor between the active material and the containing tube. There are 350 layers of each kind in such a tube.

The proper number of positive electrodes, depending upon the desired capacity of the cell, are mounted on one of the poles spaced by nickelled steel washers, the whole being clamped by end nuts on a

horizontal rod. The negatives are similarly mounted on their pole, there being always one more negative than positive electrode.

The two groups are then nested, as shown in Fig. 215, adjacent positives and negatives being mechanically separated by vertical, hard rubber rods. The hard rubber "ladders" are provided with grooves into which the edges of the electrodes fit. The entire mass is then placed into the steel can or jar, resting on the hard rubber stools or supports shown at the bottom.

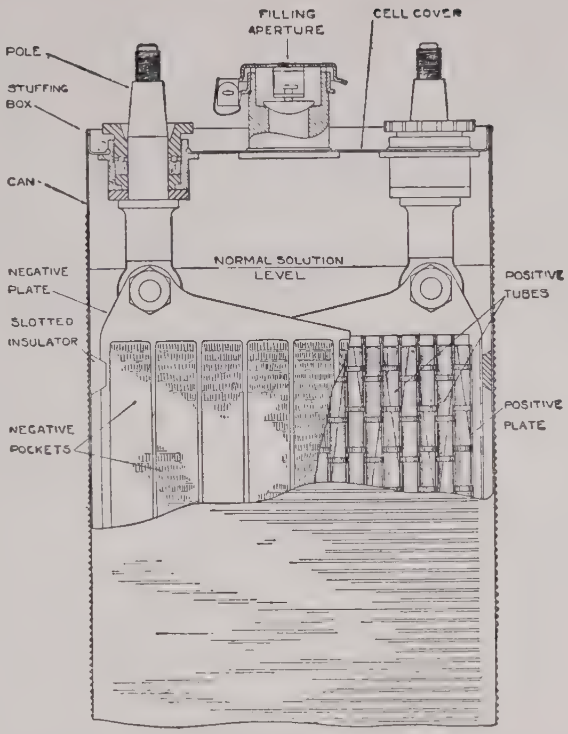


Fig. 217.—Part Section of Cell.

The can or containing jar, Fig. 216, is of nickel plated steel, corrugated as shown. The bottom is welded in, and, after the elements are placed inside, the top is welded on, thus producing, with the stuffing boxes around the poles, a compact, strong, hermetically sealed vessel.

The filling cap, shown on the top, Fig. 217, when opened, admits of the addition of distilled water to the cell from time to time or for removal of the electrolyte at the end of ten or twelve months of use, depending upon the work to which the battery has been subjected. This filling cap also acts as a check valve to permit the gas given off by the cell to get out, but preventing external air or foreign substances from getting into the cell.

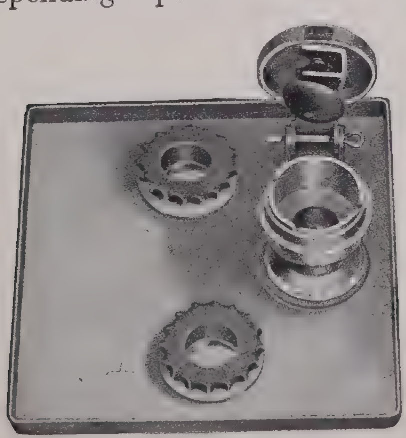


Fig. 218.—Top of Cell Open.

The top of the cell is shown in Fig. 218, with the filling valve and vent open. This filling valve serves the three purposes, to provide for the escape of gases formed on charging, a means of testing the depth of the electrolyte over the plates, and for filling in electrolyte.

The depth testing is done, as shown in Fig. 219, by a glass tube, which is dipped in until it rests on top of the

plates. If the top of tube is then closed by the finger, and the tube lifted out, a short column of liquid in the end of the tube indicates the depth of fluid above the plates.

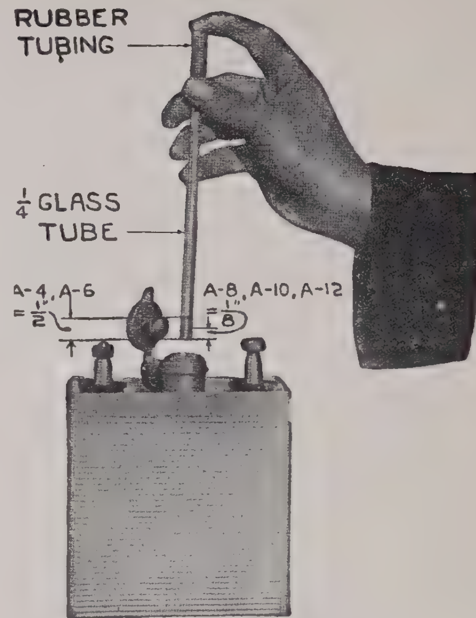


Fig. 219.—Cell Filling.

For rapidly and properly filling the cells an electrical apparatus has been provided as shown in Fig. 221. The large tank is filled with pure water, and connects to the filling nozzle, which is so constructed as to allow of two electrodes from a testing battery to dip into the cell to the depth at which the liquid should stand.

If the solution is below the level, a bell in circuit will not ring; water is then added until the bell does ring, showing it is up to the level.

We have already referred to the fact that there is no simple instrument except specific gravity beads available to show the condition of a lead acid cell. In the alkaline cell even these would not indicate, and anyway could not be seen through the steel can. An ampere hour meter is used sometimes, although it is a somewhat expensive and delicate appliance. It runs one way, and registers the ampere hours put in, and on discharge it runs the opposite way back to zero, showing the battery is empty; it is shown in Fig. 222.

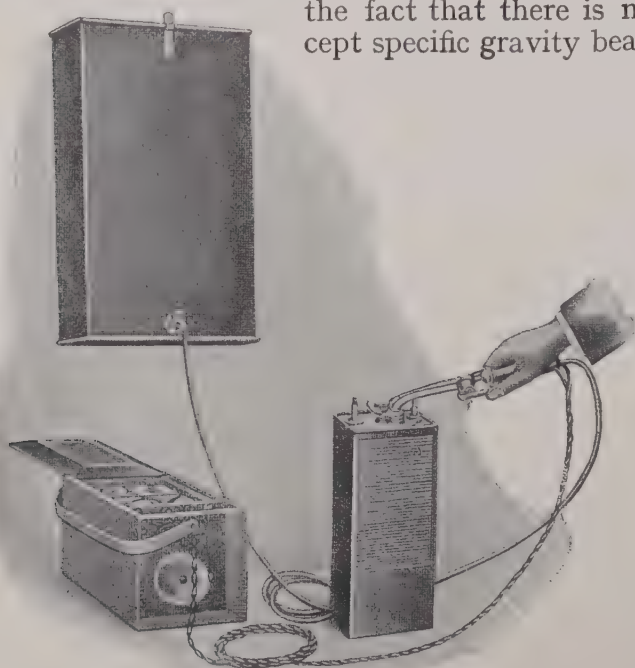


Fig. 220.—Cell Filling.

The Edison battery

is made up in many sizes and shapes, from the one ampere hour cylindrical cell to the 15,000 ampere hour submarine cell. Fig. 222 shows the make up of five cells into an A-8H. battery, and with the dimensions given in inches.

As to the theory of chemical reaction:

Starting with oxide of iron in the negative, green nickel hydrate in the positive, and potassium hydrate in solution, the first charging of a cell reduces the iron oxide to metallic iron while converting the nickel hydrate to a very high oxide black in colour. On discharge, the metallic iron goes back to iron oxide and the high nickel oxide goes to a lower oxide, but not to its original form of green hydrate. On every cycle thereafter, the negative charges to metallic iron and discharges to iron oxide, while the positive charges to a high nickel oxide. Current passing in direction of charge or discharge decomposes the potassium hydrate of the electrolyte, and the oxidation and reductions at the electrode are brought about by the action of its elements. An amount of potas-

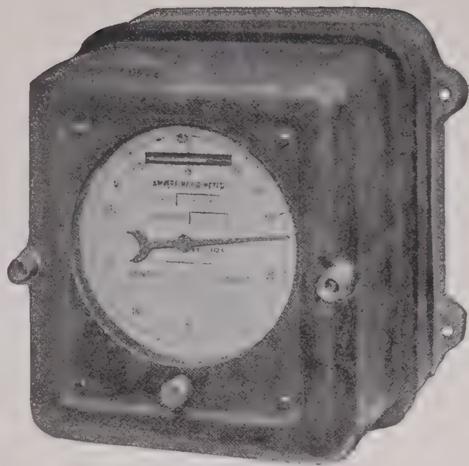
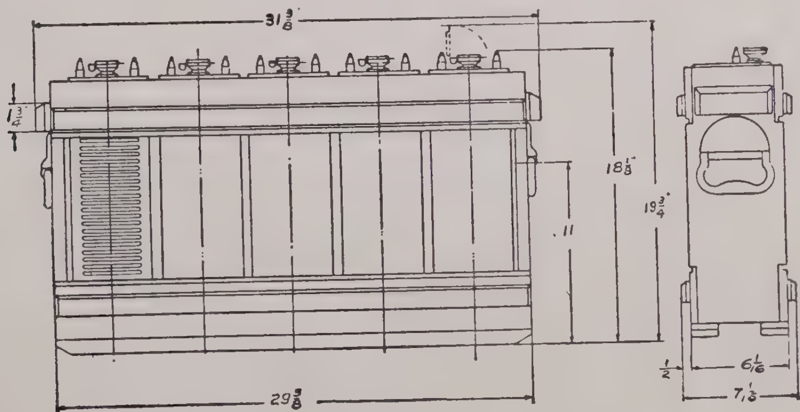


Fig. 221.—Indicator of Charges and Discharges



5 Cells A-8 H.

Fig. 222.—Battery Dimensions.

sium hydrate equal to that decomposed is always reformed at one of the electrodes by a secondary chemical reaction, and the consequence is there is none of it lost and its density remains constant.

The eventual result of charging, therefore, is the transference of

oxygen from the iron to the nickel electrode, and that of discharging is a transference back again.

The number of positives and negatives assembled on their respective poles depends upon the desired ampere hour capacity of the cell. Each Type A positive plate of 30 tubes is rated at $37\frac{1}{2}$ ampere hours. In reality it has a capacity of $42\frac{1}{2}$ ampere hours. Hence an A-4 cell, consisting of four positives and five negatives, is rated at 150 ampere hours, but will deliver 170 ampere hours.

The four positives are supported on a horizontal rod, forming part of the pole or terminal. They are spaced apart by nickelled steel washers, and clamped firmly by a nut on each end of the rod. The five negatives are similarly mounted on their pole.

The two groups are then assembled so that adjacent plates are of opposite polarity, the two end plates being negatives, of course. The assembly is then placed in a form and hard rubber rod separators are placed between plates in such manner and to such number as will prevent any tube from moving from its correct position, even if it were otherwise unsecured. Therefore, internal short circuits of the Edison battery are eliminated. In order that this rigidity of construction may extend to the edges of the plates, there are placed thereon two hard rubber "ladders," each of which has grooves into which the plates fit. The compact mass is then ready for the can.

The can is made up of a sheet of nickelled steel, which has been corrugated and bent into shape to form the sides and ends. This leaves two abutting edges which must be joined. Here we come to a most interesting process: The sheet thus formed is clamped rigidly in the welding machine, in such manner as will force the two abutting edges together. Then the carriage of the welding machine is fed, slowly, under an oxy-acetylene burner, the intense heat being concentrated at the seam. In a few seconds the weld is made. The seam is as strong as any other part of the can. The bottom is next inserted, and similarly welded to the can sides and ends. Then, after inspection, it is ready for the elements.

The hard rubber "stool," or plate support, is placed in the can bottom and the compact grouped elements inserted. Two thin sheets of hard rubber are next placed between the outside negatives and the can ends and, after a hard rubber washer is slipped over each pole, the top is placed in position and *welded on.*

A hard rubber bushing is next placed over the poles so as to insulate them from the can top. Into the little well around each pole is placed a pure gum gasket, followed by a metal ring. The hard rubber threaded glands are forced home, resulting in the compression and expansion of the gasket, with consequent sealing around the poles.

Mounted on the top, and situated between the two terminals, is the gas vent and filling aperture combined. This consists of a seat, a hemispherical valve, and a top actuated by a spring to remain fully open

for filling, or closed for operating, as desired. The valve is so arranged that, as the gas pressure in the cell rises sufficiently to raise it, the escaping gas flows by and out under the spring-actuated top. It is evident, therefore, that gases from within the cell can get out, but impurities, air, etc., from without, cannot get into the cell.

After complete assembly, the electrolyte is put into the cell. This is composed of 21 per cent. solution of chemically pure potassium hydrate and distilled water, to which is added a small amount of lithium hydrate. The object of this lithium is to cause the active material within the positive electrode tubes to swell, so as to make exceedingly good electrical contact with the flake layers and containing tubes. The specific gravity of the electrolyte is 1·236 at 65° F.

The cells are assembled into batteries and charged and discharged three times. Inspection in this department is exceedingly thorough also. Potential difference and voltage readings around each cell are taken every hour during charge and discharge respectively. If a cell does not come up to standard in voltage and ampere hour capacity, or if it acts peculiarly, *it is rejected.*

Having passed this final test, the cell is heated to 130° F. and dipped into a melted insulating compound which Mr. Edison produced for this purpose. It is called tetra-chloride of naphthaline. This forms an impervious covering for the can. It does not get brittle or crack at low temperatures nor lose its mechanical or electrical qualities at high cell temperatures.

Each cell is supported in a steel cradle and held down by a steel clamp, both of which are firmly secured to the tetrol covered wooden trays. This tray mounting is so substantial that the most severe "bumps" fail to disturb the cells in any way.

The poles are tapered and have nuts on top. Over this taper fits the connector between the cells, brought to excellent contact by the taper, when forced snugly home by the top nuts in connecting up the cells for service.

Now as to the performance of this battery:

On December 4, 1908, a one-ton Lansden truck, owned by the Edison Phonograph Works, was equipped with a sixty-cell Type A-4 Edison battery. The Type A-4 cell is rated at 150 ampere hours. A test of these cells at the time showed 180 ampere hours capacity.

Four months later the cells were again tested, showing an increase in capacity to 203 ampere hours, in practical work.

A few days over three years from initial installation, they were again tested, and showed a capacity of *205 ampere hours.*

They are still in service, and with no indication of having deteriorated in the least.

The odometer showed a total of 20,932 miles for 1,104 days' working. From this total must be deducted 188 days the truck was idle during

Sundays and holidays, leaving 916 days of actual running, or an average of 23 miles per day.

This truck has a capacity of fifty miles per normal charge of battery.

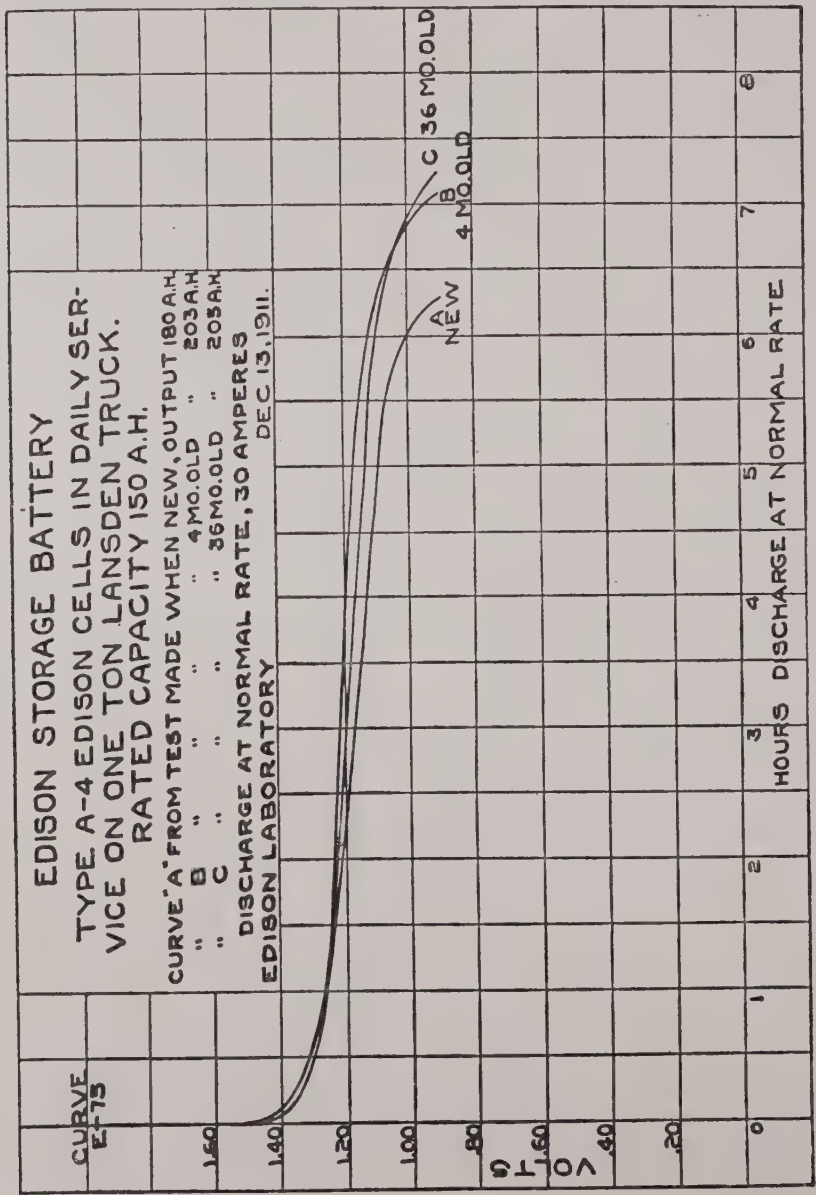


Fig. 223.

Therefore, the battery was not half discharged at the end of any day's run.

Notwithstanding this fact, and furthermore that the normal charge for a Type A-4 battery is at *30 amperes* for only *seven hours* when totally

discharged to one volt per cell, *the battery in this truck was charged at the end of each working day at 35 amperes for eight hours.*

It is apparent that it therefore received 916 cycles of enormous overcharge and only half discharge each time.

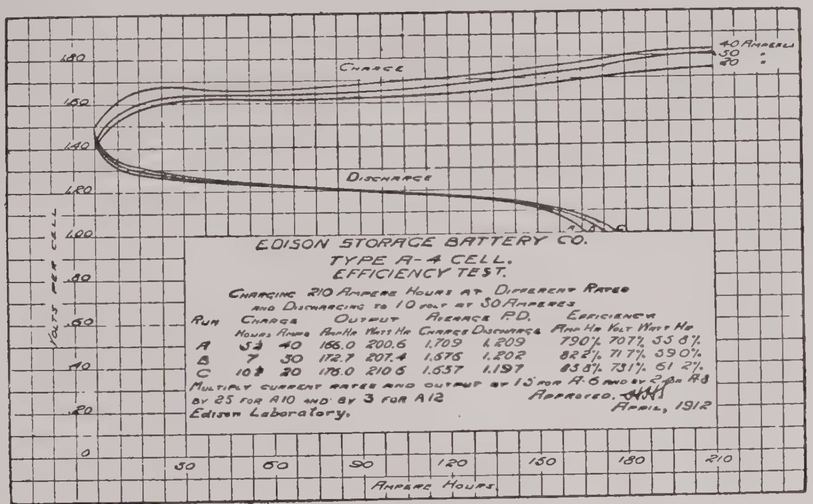


Fig. 224.

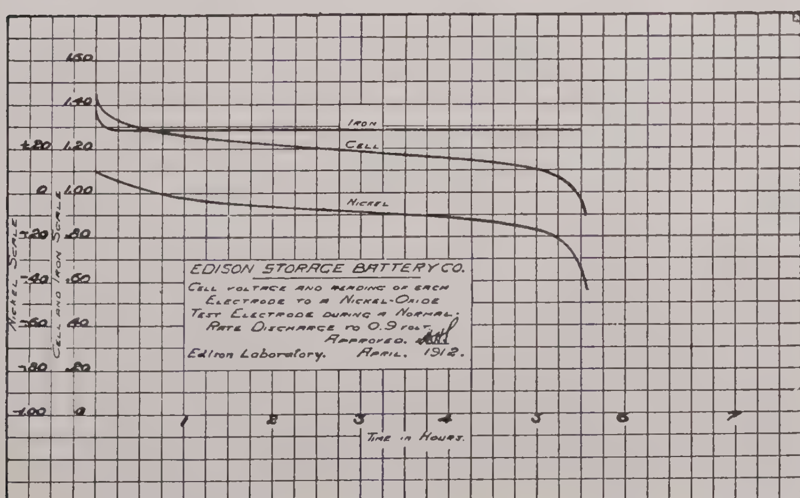


Fig. 225.
Charge and Discharge Curves.

Yet it shows a capacity of 205 ampere hours—over $1\frac{1}{3}$ times its rated capacity—at the end of this very drastic treatment.

The curves Fig. 225 are plotted from tests on an Edison A-4 battery in daily use on this Lansden truck.

The output and efficiency of a battery are of the utmost importance. Curves 224 are the results of efficiency tests which require no explanation.

The output of an Edison cell is determined by the capacity of the

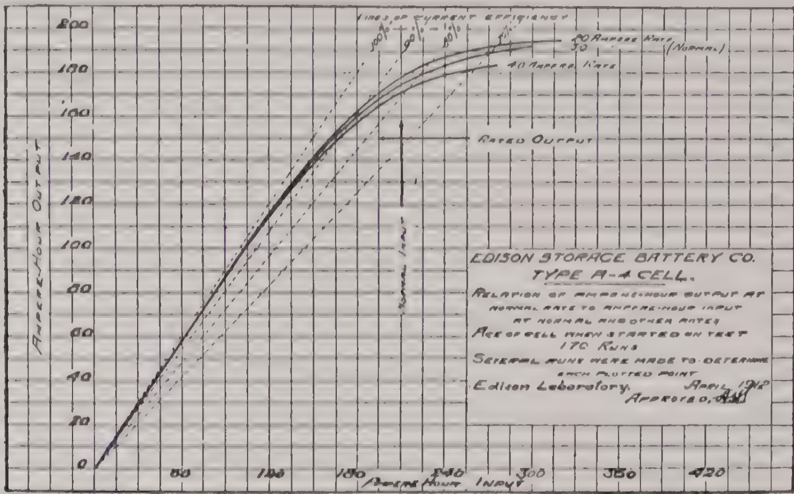


Fig. 226.—Current Efficiency.

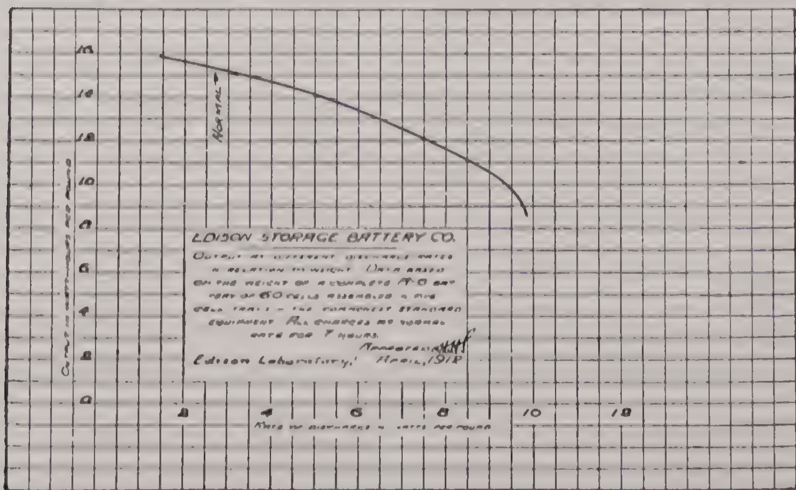


Fig. 227.—Weight per Watt Hours.

positive, or nickel, electrode. This is shown by the individual electrode curves of Fig. 225. It has been found best in every way to design the cell with a sufficient allowance of iron active material to give considerable excess capacity to the negative electrode.

Full Data of the Cell

Cells do not have as high capacity when new as after some weeks of use. The betterment comes from an improvement of conditions in the nickel electrode, which is brought about by regular charging and discharging. Occasional overcharging expedites this self-formation and is recommended. Every cell manufactured is given three overcharge runs before leaving the factory, which is always sufficient to bring the capacity above the rating. An accretion of capacity will continue for twenty, or more, subsequent runs; therefore, results of tests made earlier than the twentieth run cannot be considered typical. The term "run" is used to mean a full charge and complete discharge.

REFERENCE TABLE OF ELECTRICAL DATA ON INDIVIDUAL CELL BASIS

Type of Cell:	B-2	B-4	B-6	A-4	A-6	A-8	A-10	A-12
Weight in Pounds :	4·6	7·4	1·05	13·5	19·2	27·5	34·0	41·0
Ampere Hour Capacity :								
Rated Capacity—Ampere Hrs.	40	80	120	150	225	300	375	450
Normal Actual Output (7 Hr. Charge)—Amp. Hrs.	42	84	126	168	252	336	420	504
Maximum Output on Overcharge—Amp. Hrs.	48	95	142	190	285	380	475	570
Watt Hour Capacity :								
Rated Capacity—Watt Hrs.	48	96	144	180	270	360	450	540
Normal Actual Output (7 Hr. Charge)—Watt Hrs.	50·4	101	151	202	302	403	504	605
Maximum Output on Overcharge—Watt Hrs.	57·0	114	171	228	342	456	570	684
Output Per Pound of Cell								
Rated Capacity per pound—Watt Hrs.	10·4	13·0	13·7	13·3	14·1	13·1	13·2	13·2
Normal Output per pound (7 Hr. Charge)—Watt Hrs.	11·0	13·6	14·4	15·0	15·7	14·7	14·8	14·8
Maximum Output per pound—Watt Hrs.	12·4	15·4	16·3	16·9	17·8	16·6	16·8	16·7
Discharge Rates :								
Normal (5 Hr.) Rate of Discharge—Amperes	8	16	24	30	45	60	75	90
Maximum Rate for Intermittent Discharge—Amperes	50	100	140	180	225	300	350	400
Watt Equivalent of Normal Ampere Rate	9·6	19·2	28 8	36	54	72	90	108
Watt Equivalent of Maximum Ampere Rate	36	72	105	133	187	249	301	352
Average Voltage :								
Discharging at Normal (5 Hr.) Rate—Volts	1·20	1·20	1·20	1·20	1·20	1·20	1·20	1·28
Discharging at Normal (25 Hr.) Rate—Volts	1·28	1·28	1·28	1·28	1·28	1·28	1·28	1·20
Discharging at 5 times Normal (1 Hr.) Rate—Volts	0·84	0·84	0·84	0·84	0·84	0·84	0·84	0·84
Internal Resistance :								
Mean Effective Internal Resistance—Ohms.	0·012	0·006	0·004	0·003	0·002	0·0015	0·0012	0·001
Electrical Efficiency :								
Normal Ampere Hour Efficiency—Per cent.	82	82	82	82	82	82	82	82
Normal Watt Hour Efficiency—Per cent.	80	60	60	60	60	60	60	60

The output and efficiency of a cell, working at ordinary temperatures, depend upon three factors—the rate of charge, the amount of charge, and the rate of discharge. Fig. 226 shows the relation of current output to current input when a cell is given different lengths of charge at $\frac{2}{3}$, 1, and $1\frac{1}{3}$ times normal rate. It will be seen that for low inputs the efficiency is very high and practically the same for the different rates of charge. Farther along the curves separate slightly. Notice that the point taken as the normal input (210 ampere hours for A-4) comes pretty close to the sharpest part of the bend.

An output of 9 or 10 watt hours per lb. of battery is good performance for a lead cell at normal discharge. From curve Fig. 227 it will be seen that the Edison cell, at $4\frac{1}{2}$ watts per lb. discharge gave an output of 14 watt hours per lb. and 10 watt hours per lb. at $9\frac{3}{4}$ watts per lb. discharge.

Per watt hour per lb. of battery the Edison battery has the advantage very much over the lead battery. The watt hours per cubic foot of battery is pretty much the same as in the lead cells.

THE MOTOR

When the electric car becomes more common, it will soon be found out what design of motor will prove best.

The motor might act as a brake going down hill, provided its speed was so great that it overpowered the electromotive force of the accumulator; it would then be charging the battery. But if the battery, as it must, overpowers the back E.M.F. of the motor at the maximum speed of the car, then in order to brake the car and charge the battery going downhill the speed of the car must exceed the maximum considerably, and that would be rather dangerous on a downhill run. Of course by means of grouping the battery into two series parallel sets, when going downhill braking and charging would go in at a little under three-quarters full speed of car. But these devices fail often at most critical moments; however beautiful and simple in theory, we must remember their operation is in the hands of a man who knows nothing about it theoretically, and who may forget for a few seconds what he should do.

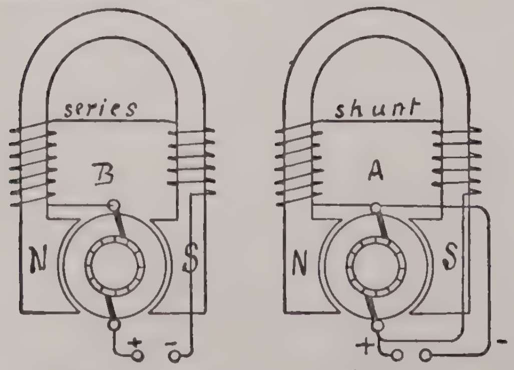


Fig. 228. Fig. 229.
Electric Motors.

All the small advantages to be gained by this braking and charging are not worth the risk of accident, nor the complication entailed.

The motor, however, may be used for braking the car, by cutting off the current from the battery to the armature, and leaving it "on" in the field magnet coils, and then short circuiting the armature through a resistance sufficient to prevent an abnormal current in the armature. This can be done only with a shunt wound motor.

The simplest motor is the series motor, Fig. 228, from which it will be seen that the circuit is one complete through armature and field coils. The shunt wound motor is shown at A in diagram Fig. 229, from which it will be seen that the current divides, one portion, a small fraction of the whole, at full load passing through the magnet winding and the other portion through the armature. The shunt motor tends to run at constant speed under varying loads.

Variations of speed in an electric car are obtained for the following purposes.

(*a*) Hill climbing.

(*b*) Slow speed, moderate speed, and high speed on level.

(*c*) Control on downward gradient.

In hill climbing we desire to mount at the highest safe speed. The current in the motor must be the maximum it will carry without overheating. To regulate the speeds on the level the E.M.F. in the series motor is reduced or increased.

To regulate the speed on the down gradients ordinary brakes may be used.

If only one motor is employed then the various speeds may be obtained by series parallel grouping of the cells of the battery by means of the controller. Thus all in series we get the highest E.M.F. and the highest motor speed. Put in two parallel series we get half the E.M.F. or half speed, and four parallel series we get a fourth of the speed.

To a large extent the electric motor is self-regulating on an average road: on an up grade it automatically slackens speed slightly and takes more current, on the level it picks up some speed and takes less current, and on the down grade it increases in speed and takes still less current, provided always, of course, that the gradation is not great.

The best motor would be a separately excited motor—that is, one in which the field excitation could be varied at will independent of the armature current. This is difficult, however, to obtain on a car where we want sometimes a high voltage on the field coils and a lower voltage on the armature, and sometimes vice versa. This cannot be done very economically with one battery and a series parallel control. It would require two batteries, one for armature and one for field excitation.

The arrangement of the motor on the cars depends upon the number of motors used. If a single motor is used, then we must have a differential gear on the rear axle as usual, and transmit by chain, spur, or worm gearing.

A spur gearing has been used with success with two motors, as shown in Figs. 230 and 231. One of the motors A is shown in the elevation view

Fig. 230. The two motors each gear into a front or back wheel spur gear *d*. The motors are supported by arms B, fitted to move freely on the wheel axle, and are supported at the other end by the spring C, so as to allow

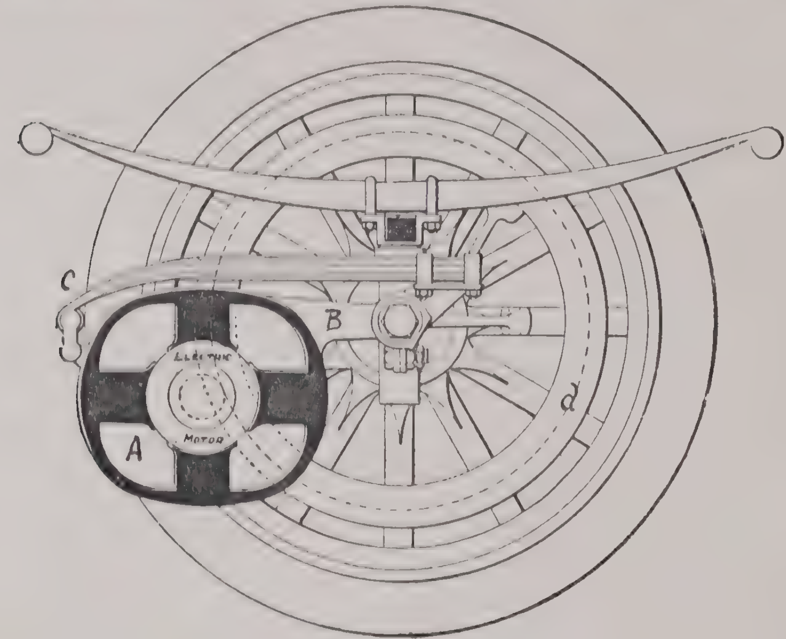


Fig. 230.—Elevation.

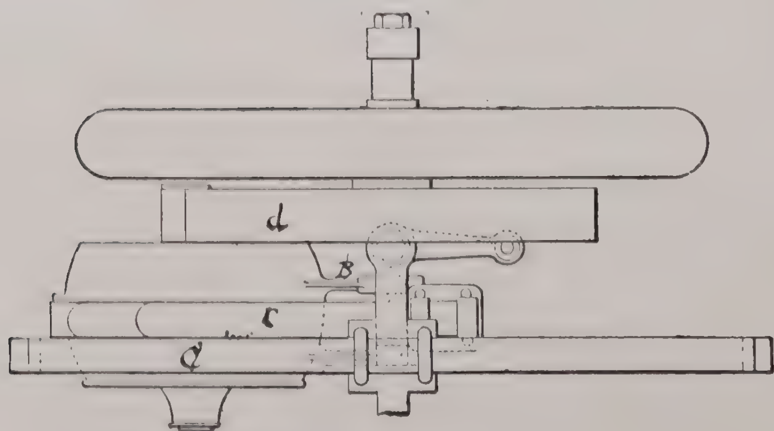


Fig. 231.—Plan.
Electric Motor and Gearing on Car.

for the rise and fall of the axle due to road inequalities. The motor is thus free to rotate to some extent around the axle.

The motor pinion is thus always in gear truly with the wheel.

With two motors it is possible, of course, to steer the car by the

motors, by making one run faster or slower than the other. There is some risk, however, of an accidental slackening of speed or stoppage of one motor, in which case the car, if going at any speed, would run into the roadside or other traffic and be beyond all control if left with one going motor only.

Probably a differential gear and steering gear will be found preferable to two-motor steering.

A plan Fig. 232 and a side view Fig. 233 are shown here of the Edison electric car. The drive is by side chains from a counter shaft direct to the rear wheels. The battery occupies the middle of the chassis, distributing the weight evenly on the four wheels.

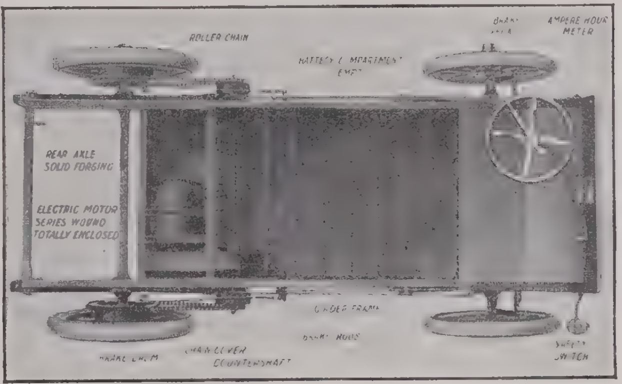


Fig. 232.—Plan of Car.

We need not here go into the matter of motor design. There are many quite excellent and suitable motors in the market, and their construction is best studied in works specially dealing with electric motors.

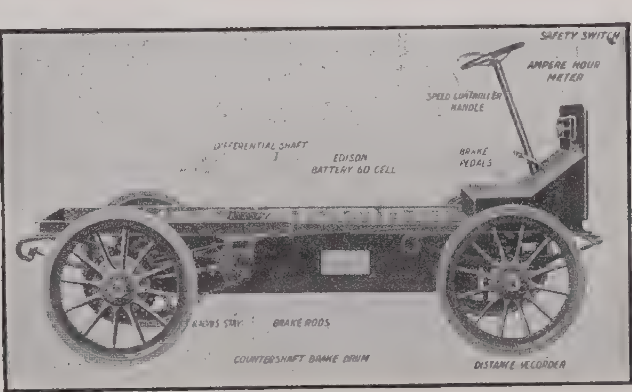


Fig. 233.—Elevation of Car.

Considering the thoroughness of Mr. Edison's methods, it may be assumed that his electric car and battery are the representative of the highest state of the art of propelling road vehicles by self-contained electrical energy. For the thousands of vehicles engaged from eight to ten hours a day in distributing goods from warehouses in towns, the electrical vehicle properly managed should prove of great advantage and the cost per ton mile much less than with petrol engines. It has its well-defined sphere of usefulness.

In America the electrical vehicle has asserted itself and has proved its value in large towns. In Boston, for example, there were only 10 electrical vehicles in 1905, increasing to 120 in 1910, and to 300 in 1912, and the rate of increase is going up still. At present there are 30,000

electric vehicles in service all over America; in 1912, 10,000 were built, 6,000 pleasure cars and 4,000 commercial cars, and it is estimated 1913 output will be 15,000.

At present rates of increase in numbers there should be 100,000 electric cars on the roads in 1915. These figures speak for themselves as to the practical success of present-day electric vehicles.

When their significance is realised in this country there will be a mild revolution in automobilism.

The well-established types of motor cars—first the petrol car, along with which may be classed paraffin, benzol, gas, and all cars driven by internal combustion engines (even the petrol electric car comes under this classification, for the "electric" portion of it is only the equivalent for a gear box), second the steam car, and third the electric car—will always remain with us, each in its own particular line of business or pleasure.

The multiplication of internal combustion engined vehicles on the streets of London and other cities has about reached the limit where their presence is felt to be a nuisance, especially in summer. The smoke and poisonous gas fumes have been abolished from the underground railways by changing to electricity as propelling power. The streets have been to a large extent preserved from pollution by horse excreta by the reduction in the number of horse drawn vehicles. But this smoke pollution of the streets is quite as bad as either of these former troubles. To a large extent the emission of evil smelling, foul smoke from petrol cars is preventable. It is due to careless drivers, mostly burning the lubricating oil in the cylinders, or more frequently in the silencers. The silencers mostly in use are very hot, so that any oil in excess in the cylinders is ejected into the silencers in a decomposing condition, and from the silencers discharged as the misty blue and yellow malodorous smoke street pedestrians are becoming too familiar with.

The introduction of a large number of electric cars would abate this smoke nuisance.

The electric car is of course lighted and the ignition operated by the same batteries which drive the car, and it is self-starting, with no gear box nor any clutch, and the only gear which may be necessary is a differential. The car is therefore of extreme simplicity.

THE ALKLUM ACCUMULATOR

This accumulator is one of the same class as the Edison. It was the invention of Prof. Jungner, a Swedish scientist, and is made by Messrs. Worsnop & Co., of Halifax, England.

In the positive plates the active material consists principally of oxyhydrate of nickel mixed with graphite, and in the negative plates of an alloy of iron and cadinium in a very finely powdered state, this alloy

being mixed with certain other substances. The proportions between all the different ingredients are determined through experiments and long experience.

The inactive retainers, which hold the active materials, are made from two very thin bands of sheet nickel, finely perforated. When manufacturing the electrodes, these bands of unlimited length, the one above the other, are separately running through small rolling mills, where they are shaped into certain profiles, the lower representing the bottom, and the upper the cover. The bottom is automatically filled while running with the active material, formed into bricks in special machinery. Cover and bottom containing the active material are now passed through another rolling mill, where they are closed up, the bands being carefully notched together along with their sides, thus forming a flat tube, filled with the active material of 10-15 millimetres width, 3-5 millimetres thickness, and automatically cut off into lengths, which are made up into plates as shown in Fig. 234. Both plates are mechanically alike. Fig. 235 shows the cell as made up ready for the containing case or can.

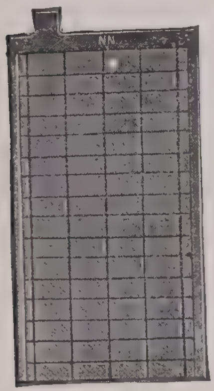


Fig. 234.
Alklum Electrode.

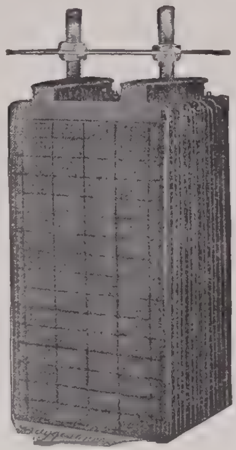


Fig. 235.
Plates Assembled.

Electrically the cell is similar to Edison's; the mechanical difference is obvious. On account of its small weight and volume in proportion to its capacity, as well as its great durability, the Alklum Accumulator has proved specially suited for tractionary purposes, such as electromobiles, electric locomotives, electric boats, as well as for any portable purposes, such as lighting of trains, motor cars and yachts, for lanterns of different kinds, ignition batteries for motor cars, for medical purposes, and so on.

CHAPTER VIII

THE NEW CAR: WHAT TO DO FIRST

We cannot here enter upon the question of choosing a car. We have discussed the various component parts fully, and from a knowledge of these the intending purchaser can judge for himself, or employ an independent, reliable advisory engineer to assist him in the choice. No general rules can be laid down applicable to all cases. But it will be gathered from the foregoing paragraphs that there are certain important points to look to. We have learned that there are three most common causes of trouble—loss of compression, misfiring, and faulty carburation.

In choosing a car it should have every precautioning device against the loss of pressure, good spring rings in the piston, valves easily got at through valve caps designed for secure packing against leakage.

The ignition system will be either magnetic or magneto and accumulator, dual or separate system.

There is not much to choose between cars in this respect, as all petrol cars are now magneto ignition or dual ignition.

The carburettor is another matter. Here we are in an inquiry upon which little authentic knowledge is available. What is required is a good automatic carburettor, under perfect control, to give the correct mixture at all speeds, and operated by one lever. Control by governor is not of much use on a car, unless it is a somewhat complicated affair. We cannot arrange a car engine to run at constant speed under all loads; if we could, then governing automatically would be easy. But the engine must be capable of varying speeds under varying loads, hence when a governor is used it is hand controlled, while the governor controls the carburettor; that being so, it is just as well to do without a governor, and control the carburettor direct by hand. A purchaser may reasonably require some guarantee, or proof, of the efficiency of the carburettor, stated in pints of fuel consumed per horse-power hour, at normal full speed.

If the governor relieved the driver of all the use of accelerator pedals and throttling levers, it would be of use; if not, then it is only an additional source of possible failure.

Then there is the choice of wheels, wood wheels or wire wheels; whether to carry a spare wheel or spare tyres, or both—questions which involve the amount of cash the purchaser is prepared to pay for the car.

The price of a plain car without spares and no extra fittings may be £300 to £400, but if one adds a spare wheel, and a whole complement of other spares, with roadside repair outfits, have dual ignition instead of magneto only, electric lighting, shock absorbers, a fanciful horn, and many other extras, the price mounts up surprisingly.

Then again, in choosing a car the use to which it is to be put is an important factor. Some cars are to be used in town only; others for general use, town or country, others in the country only. In the first case spares and other things may be dispensed with, and a simpler car altogether will suit. Then there is the racing car and the touring car, with special features.

Then we have the steam car, which may fill the requirements of some people, those who understand steam boilers and engines.

And now the electric car is offered, not for all purposes, but for many purposes. Its chief advantages are simplicity of mechanism and perfect ease of control.

It has no ignition, compression, nor carburettor troubles or care, carries no combustible fuel, is silent under all circumstances, creates no "smells," has no change speed gear, and is of course electrically lighted.

Against all this there is the battery charging at intervals of six to ten hours' running, or relays of batteries; there is the weight of the battery on the car tyres. But on fairly good roads, and where the battery charging or relaying is provided for, these two requirements are not formidable.

For town use and for commercial use in towns the electric car claims attention.

Cycle cars and motor bicycles are chosen in the same way, taking the price and the use to which they are to be put into account. A good deal depends upon report by users. An owner satisfied with his car, motor cycle, or cycle car recommends the same make to others. The performance of the machine in actual service on the road is, after all, the safest guide. But it is not to be supposed that because an owner who runs about London is satisfied with a certain car that a similar car will satisfy an owner elsewhere and requiring different uses for the car.

Having chosen a car, and received it, the new motorist, if he has not already received instructions as to its driving, will require to become fully acquainted with its parts and its handling. It is well to have a course of instruction on motor care and driving before purchasing a car. If that cannot be had at a garage or school, a chauffeur may be hired to give the first lessons, or the maker will hire a driver to instruct the purchaser for a week or so.

The makers nearly all issue good books of instruction for the care and management of their cars, and if these are studied they give great assistance to the owner.

In any case, the first thing to do is to start the engine and become

familiar with the control of it by throttle, and its ignition, advance and retard.

Before starting the engine look to the water in the cooler or radiator, and to the petrol in the tank, and see that the oiling of the engine has been carefully attended to, and jam on the side brakes to keep the car from moving while working at the engine. Run the engine at different speeds and for an hour or more—in fact, as long as is necessary to make the learner thoroughly acquainted with starting the engine and controlling it by throttle and ignition. Full instructions will be found in the makers' book as to the direction in which the levers are to be moved to effect the control. But this can be traced out, if necessary, by following the connection between the levers and the throttle and magneto, a rather tedious process and not necessary with many cars.

Having seen that the engine starts all right and become familiar with its control, the car may be started and the learner become familiar with the steering wheel and steering, and the foot and hand brakes. Before starting the whole chassis must be oiled as per makers' instructions. Unless the learner has had some previous driving experience he will be all the better for the company of one who has experience on a first run. If the petrol supply is pressure fed, see that the pressure is about 2 lb., and if not, pump it up by hand pump, usually on the dashboard, and that all the taps are open for the supply to the carburettor.

It is also necessary to see that the tyres are at their proper pressure, and if spare wheels or tyres have been provided it is safe to "try them on," if for no other reason than to become accustomed to the work and make sure they are all there.

In preparing a new car for first runs, go slowly, look well into everything so as to recognise its use and that it is all right. And the same in setting out on first runs, go slowly at first. However much experience one may have with other cars, the new one will have its own peculiarities to be observed.

CHAPTER IX

OILS AND FUEL

As to fuel, petrol still holds as the best of all volatile oils or spirits as fuel for internal combustion engines. Naturally it has risen in price, as the demand has enormously increased and is still increasing.

Benzol is at present the only substitute, and as it is a product of coal distillation its price is regulated by that of coal, and the demand for benzol is also going up. For pleasure cars the price of fuel is not of great consequence, but for commercial cars it is a serious question.

For the commercial car there can be small doubt that some means of using cheaper oils as fuel will be devised. At the moment these vehicles are in a transitory stage, and both makers and users are averse to departing from the petrol or benzol system using a carburettor. The cheap heavier oils require a vaporiser, and must have a preliminary heating up before starting. This is an objectionable feature, but not an insurmountable obstacle to their use. It is satisfactory on many hundreds of motor boats.

We need not here further discuss the fuel question ; it is not an engineering subject so much as an economical and financial one. It is one, however, well worthy of the attention of commercial car makers, who should encourage the invention of apparatus to enable the use of cheap oils as fuel.

There can be no mistaking a good from a bad fuel. It tells instantly on the running of a car. But the case is different with lubricating oils. Not one in a thousand of purchasers of lubricating oils knows the value of what he receives as lubricating oil, and the good effects of good oil are not so easily discernible nor the bad effects of poor oil so quickly discovered.

Even experts differ as to what is the best oil for various purposes.

In cars we have to use cylinder oils to withstand heat. In the bearings of the gearing and shafts and wheels, a good lubricating oil is necessary, and at joints and pins "stauffer" lubricators and solidified oil or grease is best.

But some eminent makers of cars have by long experience and their own investigation selected oils or a blend of oils which they can recommend for their cars, and some of them recommend one oil for all the car, cylinders and all, except a few places where grease can be used.

Oil users who purchase on a large scale for hundreds of engines do so on a specification, and samples taken at random from every consignment of oils are tested by an expert. In this way they get what they pay for, an oil fit for their job in the highest degree.

The cost of an oil is no criterion of its superiority for a given purpose. An oil at one shilling a gallon may prove superior to an oil at three shillings for some particular purposes.

The owner of one or two cars cannot afford to test the oils bought in. Hence many of them purchase their oils on the recommendation of their car makers.

On this subject it may be of service to quote the well-known De Dion firm's information for their clients on this subject. Every shilling spent on oil and grease intelligently applied may almost be said to save five shillings which would eventually have to be spent upon renewals or replacements of worn parts, were the car concerned inefficiently, inadequately, or casually lubricated.

In this connection, the importance of using only first-class lubricants cannot be overstated. A really satisfactory oil was settled upon only after upwards of 300 samples, among them some from the most widely known refineries in the world, had been tested, both in the chemical laboratories and in actual use.

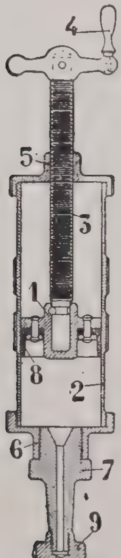


Fig. 236.
Grease Pump.

When all the oils sampled had been rejected, the company decided that it was necessary to have an oil blended to their own formula.

It is a many-purpose lubricant, equally efficient for the engine, gear box, differential, or (with the exception of the few movements lubricated by means of the grease pump) any other parts of the chassis.

It has an abnormally high flash point, has great viscosity, a minimum carbonisation, and is absolutely free from constituents which can harm any bearings to which it may be applied. The discontinuance of its use has been proved to decrease the efficiency of an engine by no less than 33 per cent. It is equally satisfactory—it would appear—for use with any engines, but, beyond doubt, no other oil, of however high price, gives anything like so good results with the De Dion Bouton engine.

The use of the most satisfactory lubricating oil greatly improves the durability, longevity, and perfection of performance of any engine.

A grease pump (Fig. 236), to force grease through screw holes into which one or other of its three connections can be screwed, is supplied with each chassis. The screw holes are normally kept closed by thumb screws or small mushroom headed screws.

The following are the references to Fig. 236:

1, Piston.
2, Barrel of pump.
3, Piston screw.
4, Handle working piston screw.
5, Threaded collar in cap of barrel, through which piston screw passes.
6, 7, Two of the three threaded unions, fitting grease screw holes.
8, Piston leather, or washer.
9, Blank cap over nozzle of pump.

N.B.—There are three threaded unions, one or other of which will fit every grease injector hole on the chassis. To get at them, unscrew 9 for the small, 7 for the medium, and 6 for the large unions.

"Stauffers" or screw down grease cups are fixed on various parts of the chassis. The cap of each grease cup can be unscrewed, after disconnecting the catch. It should be filled with grease, put back in its place, and the catch put into action to prevent its coming off. Screwing down the cap forces the grease into the bearing to be lubricated.

Everywhere that there is friction between parts a few drops of oil should be injected, unless the part is lubricated by a grease cup, or there is a hole to take the grease pump connection.

Lubrication points may be divided into two classes; some are most important, the others are not so vital. The urgent operations are those included in getting the car ready for the road—that is to say, charging crank case, gear box, and differential casing.

The other operations, although not so urgent, must not be neglected, and should be performed with particular care during wet weather. All the oil holes must be visited with the oil can and all the grease injector screw holes with the grease pump.

Most of the well-known car makers have investigated the subject of oils, and can recommend oils which have been thoroughly proved good on their cars.

Oils all become thinner or less viscous as the temperature rises, but the rate of thinning is less in some than in others, and the less it is the better for cylinder oils.

Again, some oils when exposed to high temperature vaporise and give off injurious vapours and deposits of carbon. A good oil vaporises and disappears, leaving nothing visible behind it. It should be free from acidity and should not gum.

Instruments and machines can be obtained wherewith to test oils in every way. They are expensive and require special skill in manipulation, and no chauffeur or owner would take to testing oils in any case. It therefore seems better to be guided by the experience and knowledge of the car makers, who, of necessity, have had to select the best lubricants for the cars in order to get the best possible out of them.

HEAT ENERGY OF FUEL

Petrol is a mixture of the more volatile constituents of the mineral oils obtained from the petroleum wells in various parts of the world, and from the shale in Scotland.

Scottish shale oil produces only 5 per cent. of the volatile spirit known as petrol, American petroleum 16 per cent., Russian petroleum 4 per cent.

The following table gives the usual constitution of petrol in American petroleum :

	Boiling Point.	Specific Gravity.	Percentage.
Ethereal Oil	104° to 158° F.	0·59 to 0·625	0·5
Gasolene	158° to 176° F.	0·66 to 9·67	1·5
Petrol	176° to 302° F.	0·68 to 0·738	14·0

These again can be divided up into members of the paraffin groups, but the general chemical composition of the stuff sold as petrol is approximately C_7H_{16}, with sp. gr. of from 0·68 to 0·7.

The boiling point is not of so much importance as the rapidity of evaporation. Average petrol boils at about 98° Centigrade.

Benzol, for instance, has a higher boiling point than alcohol, but it vaporises much more rapidly, hence it can be used in a common carburettor while alcohol cannot be so used, due to its slow vaporisation.

Ten years ago the early motor car experimenter was much assisted by the supply of a very high-class petrol at a cheap price. But the rapid rise in the demand for petrol caused the producers to send out petrol of higher specific gravity and less volatility. And this inferior petrol is the cause of much of the present carburettor troubles, and the different results obtained in the way of miles run per gallon by different tests on the road, tests of no value whatever.

Petrol rapidly vaporises at ordinary temperatures, taking up heat at the same time. If a drop be put on the hand it will quickly evaporate. The cold felt at the same time is due to the heat taken to evaporate the drop. If drops of various liquids, benzol, petrol, alcohol, paraffin, etc., be put on a plate the difference in the rapidity of evaporation will be seen at once.

Petrol burned with atmospheric oxygen gives off from 18,000 to 21,000 British thermal units of heat. We generally take the lower value.

Each British thermal unit is capable of producing 778 foot lb. of energy or work. It is found in practice that a fairly average engine takes about 0·75 lb. of petrol per horse-power hour. Petrol weighs about

Side Elevation of Crossley Chassis, showing Frame, Springing, and Engine Suspension.

6·8 to 7 lb. per gallon, hence a gallon of petrol consumed per hour should give $\frac{6 \cdot 8}{0 \cdot 75} = 9$ horse-power, or about 1·125 horse-power per pint per hour.

This for indicated horse-power.

But for brake horse-power the consumption is greater by 12 per cent. at least.

Hence the petrol consumed will be for brake horse-power 12 per cent. greater than for indicated horse-power. In practice a pint of petrol per horse-power hour is a fair average consumption, although 1·2 pint per horse-power hour is not unknown.

How far a motor car should travel on a gallon of petrol is a question no man can answer; it depends upon a great many factors—the losses in the engine, the losses in the transmission gear, and in the road wheels, bearings, air resistance, and other things which cannot be measured or even estimated during a road test. Too much air or too much petrol in the mixture, due to faulty carburation, is only one factor.

It would be a most interesting test on a motor car to put an electromotor in place of the petrol engine, a motor of known efficiency and with accurate electrical instruments for measuring horse-power, and to run the motor car from a tramway trolley wire system, to tabulate the results, and to compare these results with the car run by its petrol engine over the same track.

Of all the heat given by the petrol in the engine very little is used for actual propulsion; from 30 to 40 per cent. is lost in the cooling jacket, and another 40 per cent. goes away in exhaust gases; hence the amount of heat used is only about 20 per cent. of the heat given.

The petrol should give out power in an engine equal to

$$\frac{18{,}000 \times 0 \cdot 75 \times 778}{60 \times 33{,}000} = 5 \cdot 27 \text{ horse-power,}$$

18,000 being British thermal units in one lb. of petrol; 0·75 the petrol in lb. supplied to the engine per hour; 778 the British thermal units mechanical equivalent; 60 = minutes in an hour; 33,000 foot lb. per minute in one horse-power.

We find, however, by brake tests that the engine is giving only one horse-power, hence the efficiency is only $\frac{1}{5 \cdot 27}$, about 19 per cent.

We cannot hope to do much better than that. The only direction in which to move towards the cost of a horse-power being reduced is to devise the engine to use a cheaper fuel more plentifully found on earth.

η, the theoretical efficiency taken by the air standard, is proportional to $\eta = 1 - \left(\frac{1}{r}\right) 0 \cdot 408$, in which 0·408 is the ratio of specific beats of air at constant volume and constant pressure, and r is the

compression ratio; for instance, r would be $= 10$ if the combustion space in the cylinder were $\frac{1}{10}$th the capacity of the cylinder.

The atomic weights of the gases in an engine explosive mixture are roughly:

Carbon	12
Hydrogen	1
Oxygen	16
Nitrogen	14

of which the carbon, hydrogen, and oxygen are the combustibles.

The British thermal units given by the combustibles are as follows per lb.: carbon = 4,450 British thermal unit when burned to monoxide, and 14,500 British thermal units when burned to dioxide. Hydrogen = 51,700 British thermal units when burned to water. Air contains by weight 23 per cent. of oxgyen and 77 per cent. of nitrogen, and by volume 21 per cent. of oxygen to 79 per cent. of nitrogen. $\frac{77}{23} = 3{\cdot}35$, so that is the amount of nitrogen to one lb. of air. Hence one lb. of oxgyen will be contained in 4·35 lb. of air, and similarly we can find that there is one cubic foot of oxygen in 4.76 cubic feet of air.

The petrol may be taken to consist of C_7H_{16}. When the carbon is burnt it becomes $C + O_2 = CO_2$, producing $12 + 32 = 44$ lb. of CO_2, burning 12 lb. of carbon and 32 of oxygen. In other words 2·67 lb. of oxygen are required to consume one lb. of carbon.

When the hydrogen is burnt to form water, $H_2 + O = H_2O$, 16 lb. of oxgyen are required to burn 2 lb. of hydrogen, or 8 to 1.

To find the air required for fuel combustion, it is simplest to take the atomic weights, W, and multiply by the quantity in the formula (C_7) 7, being the quantity; thus in 1 lb. of fuel C_7H_{16} there will be carbon $= \frac{12 \times 7}{100}$ and $\frac{16 \times 1}{100}$ hydrogen.

The air required for the carbon will be $= \frac{84}{100} \times 2{\cdot}67 \times 4{\cdot}35 = 9{\cdot}75$ lb., and for the hydrogen $\frac{16}{100} \times 8 \times 4{\cdot}35 = 5{\cdot}568$ lb.

Therefore air required for 1 lb. petrol $= 9{\cdot}75 + 5{\cdot}568 = 15{\cdot}32$ lb. air or about 200 cubic feet of air to burn 1 lb. of petrol, approximately 9,000 cubic feet of air to one cubic foot of petrol liquid.

The theoretically correct mixture of air to petrol vapour or gas is 15·3 lb. of air to 1 lb. of petrol, or by volume 52 of air to 1 of petrol gas. But in practice more air is required.

By weight explosive mixtures varying from 10 to 1 to 20 to 1 can be used.

The weakest mixture which can be ignited depends upon the compression.

The fuel should be thoroughly sprayed or pulverised into a mist in the air with which it is to mix; the finer the spray the more rapidly it evaporates into the gaseous form. Heating the air before it enters the carburettor is the proper method of supplying the necessary heat for evaporation, far better than the jacket heating of the carburettor by hot water or exhaust.

Petrol carried into the cylinder in the form of mist or fine spray—that is, in minute globules, does not ignite at the instant of explosion, but later on, when the heat of the explosion due to the gaseous petrol present vaporises the globules, and this late combustion is inefficient.

The first essential of good carburation is the thorough gasification of the fuel, and two requirements towards that end are fine spraying and hot air supply; and these two essentials are not given the attention they demand in carburettor design.

Then another point is that the proportion of air to fuel should be constant at all engine speeds. How this is attempted may be seen in the several carburettors previously described.

Other Fuels

Benzol is the only other fuel possible at present with the ordinary petrol engine and carburettor. Like petrol it is a manufactured product, limited very much in supply.

The benzol formula is C_6H_6, specific gravity 0·885 at 60° Fahr. It boils at 176° Fahr. and distils over at 198° Fahr. It has a wide explosive range from 2·7 to 6·3 per cent. by volume of vapour to air.

From the formula it will be seen that it contains far more carbon than petrol, and therefore requires much more air for combustion. It gives 18,500 British thermal units per lb.

It has recently been used to a greater extent on motor cars, due to the high price of petrol, and has been quite successful with but slight changes in the carburettors.

It weighs more than petrol per gallon and therefore gives a greater horse-power per gallon, but its calorific value is about the same per pound. Purchased by the gallon it gives a greater mileage per shilling expended than petrol, but by the pound they differ very little in power.

A good supply of hot air is necessary to get the highest results with benzol.

On road tests petrol has given 18·5 miles per gallon, benzol 20·7 miles per gallon, Scottish shale spirit 18·75 miles per gallon on the same car with the same carburettor.

Scottish shale spirit has about 0·74 sp.gr., boils at 180° F., and distils at 112° F. It is a good enough fuel, but not plentiful, so that its price would rise if any great demand for it grew up.

Acetylene has been looked upon with high hopes as a fuel. The

great drawback to its use is the extremely rapid ignition and consequent violent explosion of the mixture with air.

Acetylene gas requires 12·5 volumes of air to form a combustible mixture for complete combustion. Its calorific value is 21,000 British thermal units per lb. and it has a volume of 14·5 cubic feet per lb.

Alcohol presents some difficulties as a fuel; its calorific value is low. Ethyl alcohol made from potatoes or beetroots has a specific gravity of 0·792 and a calorific value of 12,600 British thermal units per lb. when pure.

The alcohol for commercial purposes is denatured in Britain by adding 10 per cent. of methyl alcohol; the methylated spirit has a calorific value of 11,320 British thermal units, but water is also added from 10 to 20 per cent., reducing its value to about 10,000 British thermal units.

Alcohol can be used with double the compression considered safe with petrol, but it is too costly at present for use as a motor fuel. It, however, has the same difficulty, but in a less degree, as paraffin oil in not allowing a start from cold.

It has been proposed to use acetylene and alcohol mixed. Acetylene has a high calorific value and rapid ignition. Alcohol on the contrary has a low calorific value and slow ignition. The idea is that the mixture would have these properties levelled down and up to a medium.

It is said to have been tried and found to work well in America. But alcohol in any shape is at present out of the question in price. Further, motor owners will pay a long price for petrol or benzol as fuel before considering the use of two fuels, one requiring a generator, which, however simple, requires replenishing, cleaning out, and attention.

Kerosene or paraffin oils could and would be used with success were it not for the reluctance of road vehicle owners to adopt anything in the form of fuel gas which requires to be produced on the vehicle. Paraffin and air mixed will not ignite in the cylinders. The paraffin must be heated to form a gas which when mixed with air will explode. This heating is simply a gas producing process, quite simple and easily applied to stationary engines under fairly constant load, but when applied to road vehicles many difficulties and troubles at once arise.

Gas producers using oils have the same fatal objections, as also have coal and coke gas producers.

Attempts have been made to induce owners of motor vehicles to adopt paraffin, by using petrol to start up the engine, and then turning in the paraffin when the engine and the vaporiser are heated up. But it overlooks the principal difficulties.

It is difficult enough to get good results with the best of petrol under road vehicle conditions, and almost impossible with a paraffin gas produced in a vaporiser; speeds and load vary all the time and independently of each other, while the gas producing is beyond all control.

Acetylene has most promise as a fuel produced in the motor car, and its possibilities have by no means been exhausted. The rapid

ignition difficulty exists only in starting. It is, on the other hand, an advantage at high engine speeds.

The only other alternative is the constant pressure engine (Diesel or semi-Diesel) using common oils of cheap quality.

The adoption of simple effective self-starting appliances would simplify the fuel problem. These are coming into more common use every day.

It is not for practical engineers to enter upon speculative discussions, but it may be pointed out that spirit oils may be produced synthetically from their elements; so that although the natural supply may fail, a large supply of fuel may be in the future manufactured from the plentiful elements of its constitution. Acetylene and alcohol are manufactured articles by artificial process. It may also be possible to convert the heavier oils into lighter and highly volatile spirit oils. Upon these lines inventors are already at work.

CHAPTER X

CHASSIS CONSTRUCTION

THE frame of the motor car, which carries each part in its proper place and relation to each other, has received much attention by designers. The ordinary owner and chauffeur pay but small attention to it.

The frame has to bear heavy shocks and stresses without yielding. The engine, the body, and all the gearing are dead weights on the frame. Hence it must be exceedingly strong. At the same time it must be of smallest possible weight.

It is easy enough to design a steel structure of enormous strength

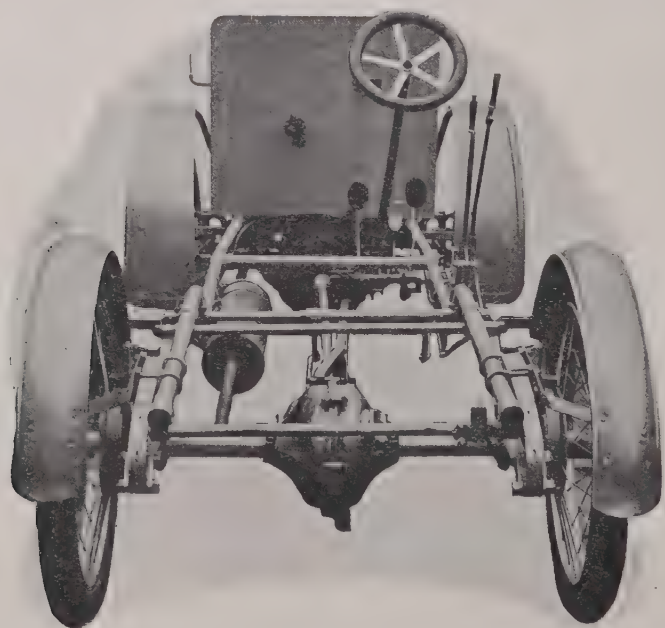


Fig. 237.—The Vox Small Car or Cycle Car. Two-cylinder, Two-stroke Engine.

provided the weight is not limited. In designing the chassis weight is limited, and therefore highest class of design is necessary.

The chassis must also be designed with an eye to carrying a body which will be comfortable and convenient for the occupants. It must also be designed to carry the engine and gear and allow of easy access to all parts.

In the beginning cars were all designed with wheel basis too short, that is, the distance between the front and rear wheels was too short, and many of them had wheel basis too narrow.

To-day the wheel basis of all cars is ample, except in the case of a few cheap makes.

Between the frame and the wheel axles, the springs are placed to give a resilient suspension to the chassis. It must therefore be rigid enough in itself to withstand the shocks and jolts on the road. In good chassis design neither the engine nor the body should contribute any-

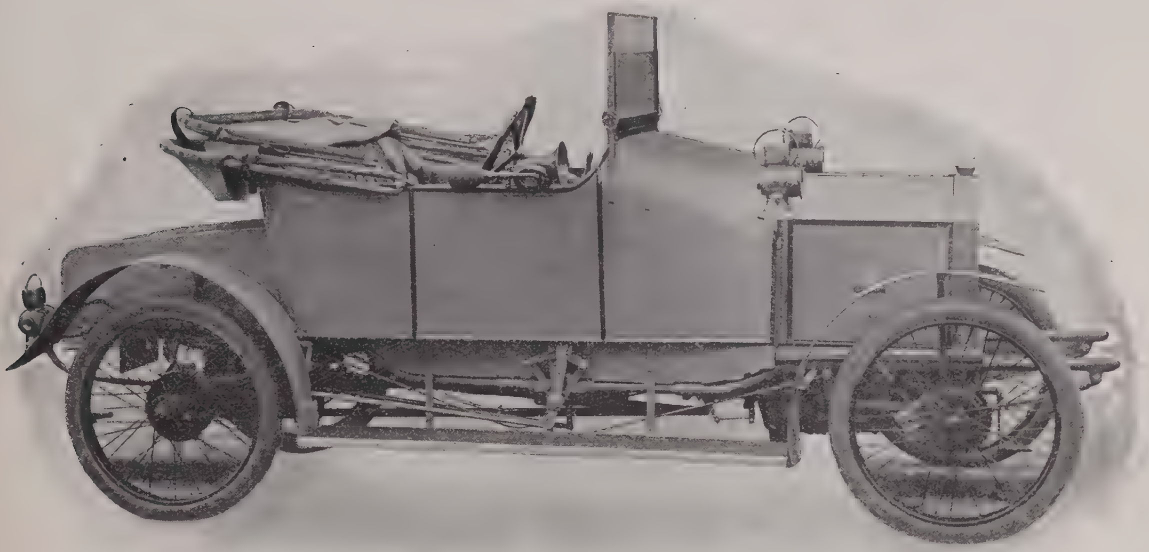


Fig. 238.—Side View of Vox Small Car.

thing to the strength of the frame. It must have all the strength required within itself.

In this chapter it is not intended to enter upon chassis designing, that is, beyond the scope of the car driver, constructor, or owner. But an examination of the points of a few of the well-known cars is interesting and brings out information on many details of the car.

The frame is made up generally of steel channel section, tapered towards the ends, the greatest depth at the centre of the chassis, to resist the bending between the supporting axles.

For light cars a tubular framing is often used with success. An examination of the various cycle cars will show different tubular designs.

Fig. 237 shows the design of the tubular chassis of the Vox car. The tubing is seamless, cranked down in the centre to get the body low, as shown in the complete view of the car, Fig. 238.

The attachment of the springs to the frame is seen and also the cross stays or tie rods.

Such a frame has some spring about it which makes for easy running, and does not cause strain or binding on the machinery or body.

In this small car the gear box and differential are one unit, the engine alone being in front. This combined gear is shown in Fig. 241.

The engine of this small car is of some interest, being a V two-stroke engine with separate air pump. The complete view of the engine is shown in Fig. 239, and the sectional view Fig. 240; and the following list refers to the different parts of the engine. The engine has two pair of cylinders, 72 mm. bore, 95 mm. stroke. The mixture is drawn into the pump cylinder from the carburettor and then passed through a spring leaf valve into the working cylinder, which has side port exhaust, and the incoming charge drives out the products of the previous combustion.

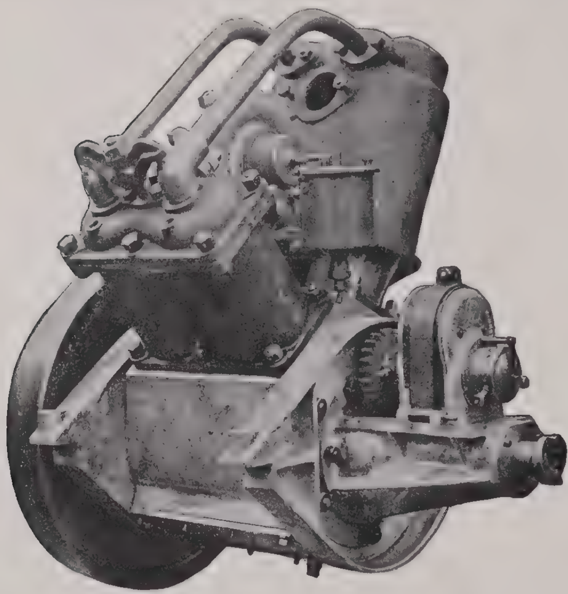


Fig. 239.—Two stroke V Engine.

The valves are of the leaf spring type, giving exceedingly quick action and silence in working. The engine has no cam shaft or gearing of any kind with the exception of the magneto drive wheels.

Reference table to Fig. 240:

A, Working cylinder.	G, Air valve.
B, Working piston.	H, Steel leaf valve.
C, Exhaust pipe.	I, Transfer pipe.
D, Exhaust ports.	J, Induction pipe.
E, Displacing cylinder.	K, Displacing cylinder piston.
F, Sheet metal leaf valve.	

For a small car the engine, gearing, and chassis are well designed. The frame is made throughout of steel seamless tubing, low cranked in the centre, giving room for two persons with comfort.

The gear box on the back axle gives two speeds, and a reverse with direct drive on top speed. The gears are of the sliding pinion type, and the differential of usual bevel wheel type. See Fig. 241.

White metal bearings are used on the front wheels and back axle.

As an example of small car chassis built with a tubular frame, this is one which shows good design.

Another tubular frame in a well-known chassis is that of the Premier

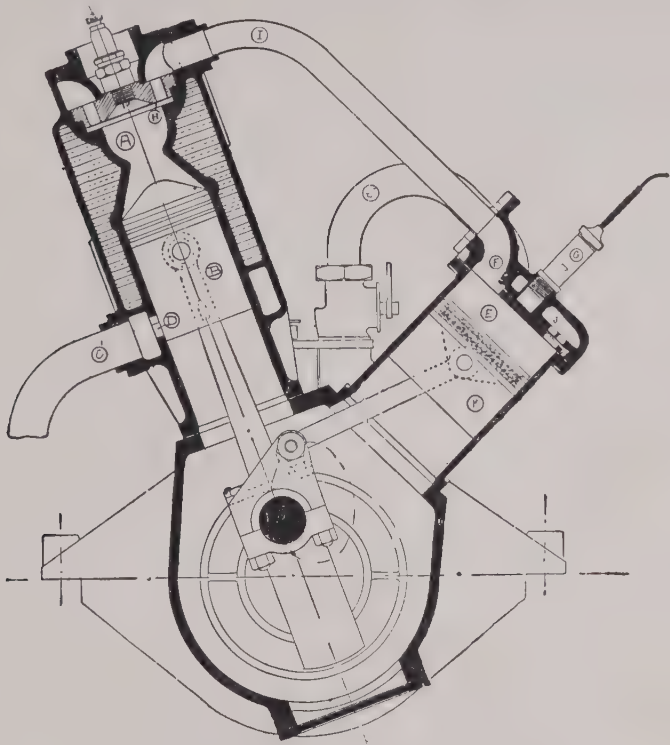


Fig. 240.—Section of Two-stroke V Engine.

small car described in Vol. II. The plan view Fig. 242 shows the chassis with the arrangement of the mechanism. All three-power mechanisms are separate, the engine in front, the gear box in the centre, and differential on back axle connected up by two chains.

The frame cross stays are shown, also the struts and stays in front under the engine. The frame is double in the centre, of truss design.

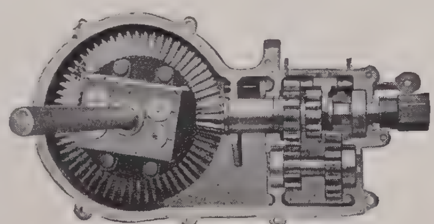


Fig. 241.—Back Axle Gearing.

A De Dion chassis is shown in Fig. 243 of tapered channel iron. The frame has a cross channel iron member at the back and cross stays of tube, with an arched channel iron cross member at the engine end where the frame is narrowed to the engine breadth. The side frame is not raised over the back axle. The three-power members, engine, gear box, and back axle, are separate, as may be seen. In more recent designs the engine is combined with the gear box in one unit.

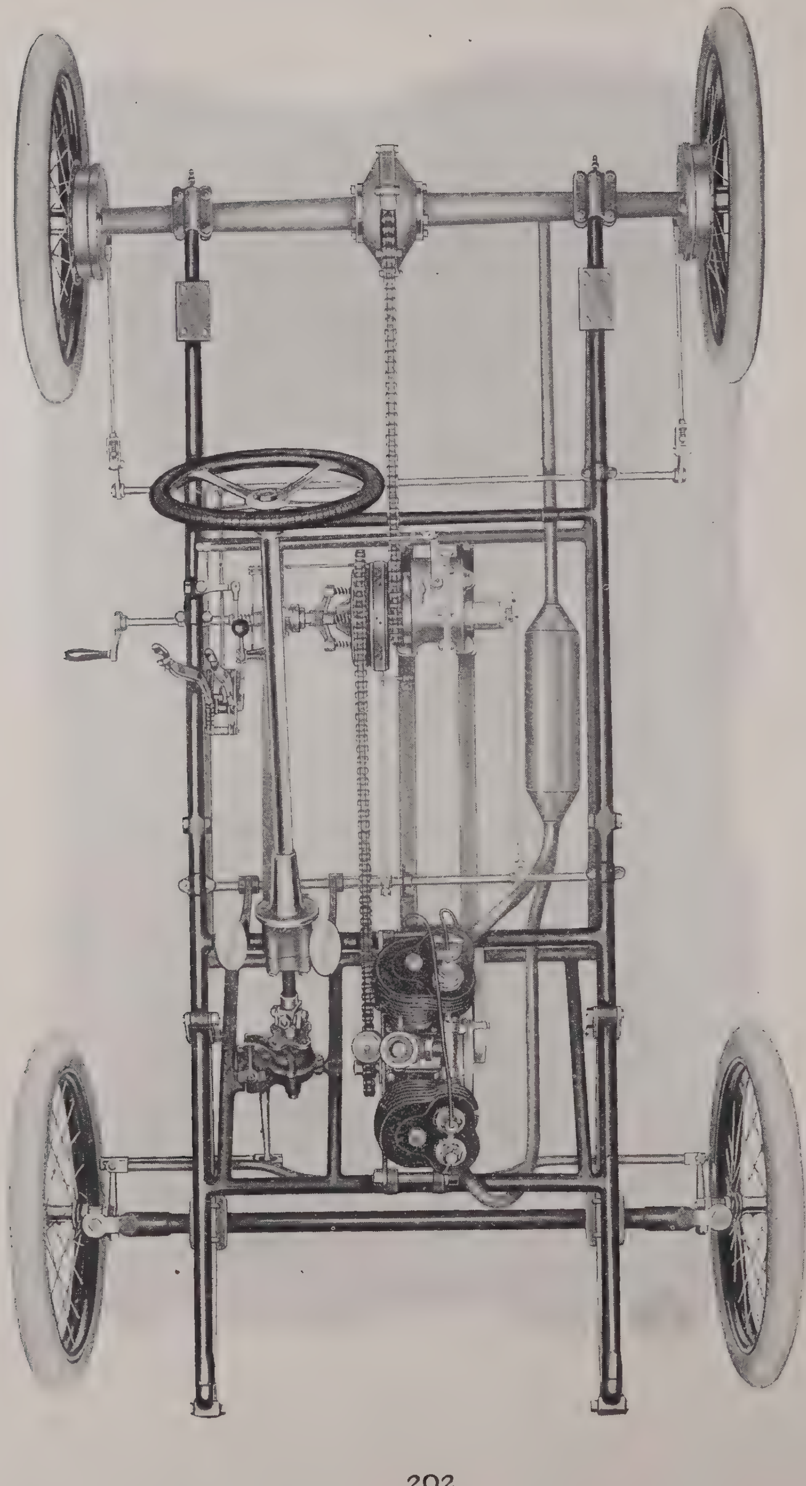


Fig. 242.—Plan of Premier Tubular Chassis.

Plate VI. shows the Napier chassis in plan and elevation. In this chassis the gear box is separate from the engine. The rear is hung upon

Fig. 243.—De Dion Chassis.

the quarter springs, the side frames bending over the axle to give a low body.

Plate VII. shows the Crossley chassis of much the same design, but with the engine and gear box combined.

The prevalence of wire wheels may be noticed in all these illustrations except the small De Dion. There is every indication that the wire wheel detachable is to be the universal wheel.

Frames are sometimes made of square tubes of thin steel stiffened by wood filling to prevent buckling; these make very light, strong frames, but are expensive.

Tubular frames are only suitable for small power cars, but for anything over 10 h.p. the channel iron frame is necessary to give sufficient stiffness.

Suspension of Engine

The unit system of engine and gear box lends itself to an excellent method of suspension on the frame. In this method the lower portion of the crank case is cast in one piece, and the front end is pivoted to the front of the frame, the rear fastened to a cross girder between the

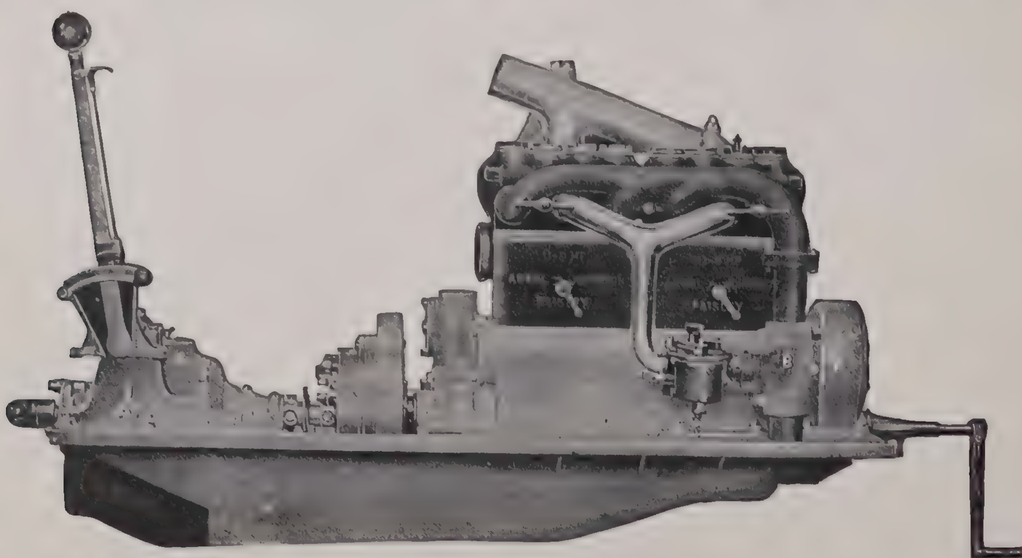


Fig. 244.—Three-point Suspension Engine Unit.

frames. This is known as "three-point" suspension. All strain comes upon this lower casting, thus relieving the crank case and gear box from the twisting and bending strains of the frame and allowing of more accurate and permanent alignment of the clutch and gear shafts—advantages of no small importance, substantially and materially improving the chassis design and construction, along with considerable benefits to both the maker and owner of the car.

We have shown the Arrol-Johnston engine in section in Fig. 169, page 131, with gear box in one unit.

In the figure here shown, Fig. 244, the engine is seen from one side, the carburettor side. The under casting is shown, a substantial boat shaped piece A. The upper face is truly planed and the engine fits down upon it, being held by the bolts shown, firmly to the casting A. The gear box C also bolts to this rigid bed. D is the two-to-one valve gear box. B a muff from which the carburettor draws hot air. This design is shown here as typical of up-to-date petrol engine practice; rigid connection between the vital parts, together with great accessibility. If at any time valves require tuning up, the wheel gears in D can be got at without dismantling anything. This gear box is shown better in sectional view

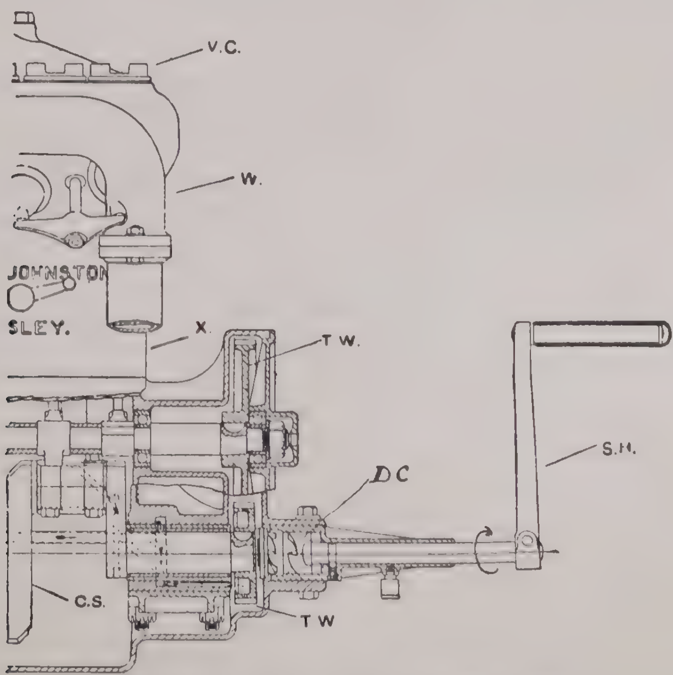


Fig. 245.—Two-to-One and Starting Handle Gear.

Fig. 245, TW, which also shows the starting handle SH. This detail of a plain starting handle has not been referred to previously in this work. DC is the dog clutch with teeth sloping one way and parallel to the axis on the other side. The clutch can be slipped into mesh when the engine is at rest, and it will pull the engine round by bringing the parallel faces together and rotating the handle as shown by the arrow.

Immediately the engine fires, the sloping sides come into contact and the handle, by their inclined plane action, is thrown out of gear.

A great many makers of motor car chassis have adopted this three-point system of suspension.

A high class chassis with a six-cylinder engine is shown in Fig. 246. Like the small Vox car the gear box is one with the differential on the

back axle. B is the differential gear box and A the gear box, C the propeller shaft. The design of the frame and springing is clearly shown.

The arrangement of a small motor tricycle chassis may here be referred to as of interest. It is that of the well-known A.C. machine. Fig. 247 is the rear wheel end in plan, and Fig. 248 shows the tricycle complete. The change speed and reverse gear is in the hub. The drive is by chain 16; the brakes are shown at 14 and 10, with straps 21, 22, the gear changing lever at 19 with the slide 13 operating toggle levers 5. The back axle is carried direct on the springs.

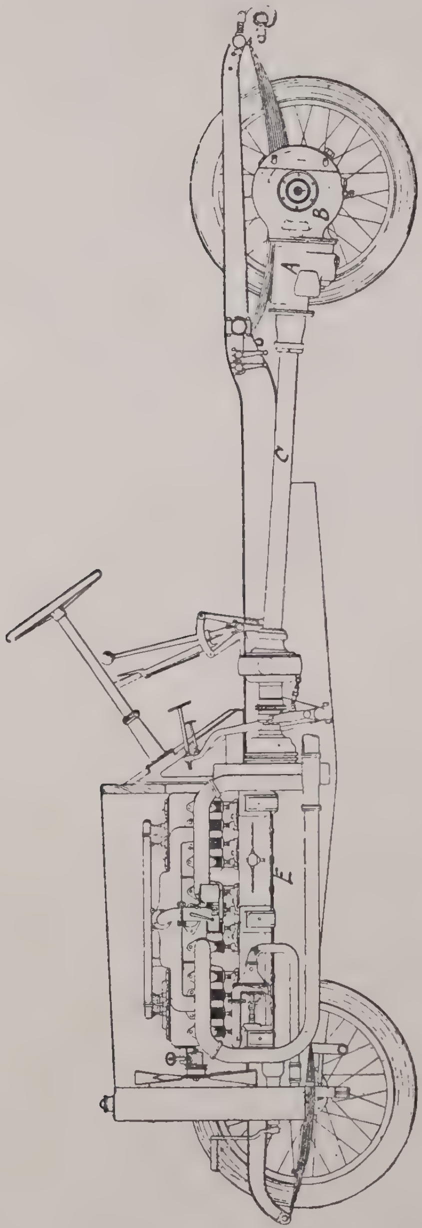


Fig. 246.—Sheffield Simplex Chassis

The automobile industry has been remarkable for its rapid growth and by the high degree of perfection of its mechanical products. Much of its rapid progress was due to the pioneer work done long before any motor cars were put forward as a commercial proposition. Much had been done in the internal combustion engine design, but it remained to be found out to what extent high speed and small weight could be carried, also how to use liquid fuel, and the carburettor had to be invented and made workable. Electric ignition was invented and worked away back fifty years ago.

The carburettor still presents difficult problems, although much improved in recent times; none of them correctly proportion the mixture under all speeds and conditions. But as its principles are becoming better understood, probably a perfect carburettor will shortly be evolved out of the many experimental ones. The main clutch and gear box are still with us as "necessary evils" indicating subjects for the inventor's attention.

The four-stroke engine maintains its popularity, and during the past two years attempts to improve it have been made in the way of sub-

stituting sleeve valves for poppet valves.

As to the future, the scarcity of petrol and its consequent high price will bring about an engine designed for cheaper fuel, especially for commercial vehicles.

The gas turbine is at present only a dream. Some think that the chief difficulty is with the high temperatures to be dealt with, but that is a mistake. The chief difficulty is to get compression before ignition, and no inventor has even suggested how to begin the solution of the compression problem.

The Diesel engine is quite a possible solution of the fuel question. It only wants time and means to put it into practice.

Rotary engines are impossible for anything but flying machines, and it is doubtful if they will hold a position of advantage even there

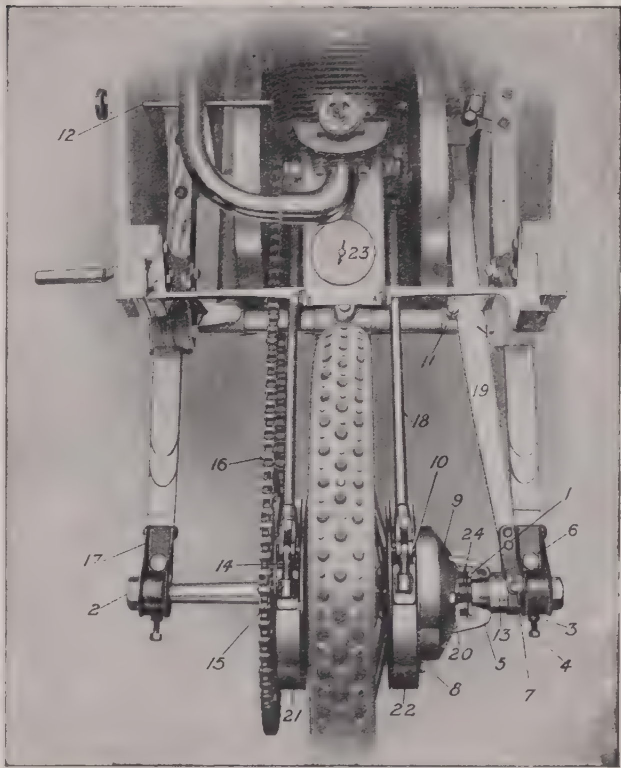


Fig. 247.—A. C. Tricycle Chassis.

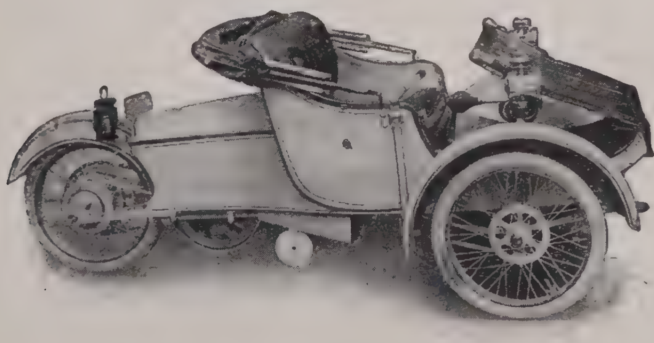


Fig. 248.—A. C. Tricycle

A COMPARISON OF ENGINES AND THEIR DEVELOPMENT

We have seen that for the smaller cars the two-cylinder engine of V type generally prevails, while single-cylinder engines are now used only on motor bicycles; but even on these small vehicles two cylinders, V type, or opposed cylinders are becoming common and we have described one with four cylinders.

Small power four-cylinder engines are rather expensive power units, but the increased flexibility of the power and smooth running are well worth the increased cost.

Two-stroke engines are still favoured by some makers and the recent examples are in some respects improvements on previous designs. We have no authoritative results of comparative tests between two-stroke and four-stroke engines of recent date, but from theoretical and practical reasons the four-stroke engine should be the most economical of fuel.

For larger cars the four-cylinder four-stroke engine has become in the hands of the great makers the standard type. It has taken years to arrive at its present-day perfection and much expenditure of means, but the result is well worth it all. It is a marvellous machine from its efficiency point of view, not only as to fuel consumption, but taken all over, in reliability and power developed.

A properly designed four-cylinder engine of well planned monobloc type is no larger than an old type two-cylinder engine of much less power, but it has other appreciable advantages besides economy of space.

The simplicity of construction is evident, and every day's experience only goes to prove the long foresight of the inventor of the four-stroke cycle, Beau de Rochas; and at the present day it may be taken that the four-stroke for cylinder motor is almost an ideal machine working upon primary principles. Whatever shortcomings it has are inherent in the principles of its operation, such as not being self-starting and requiring a gear box, and water cooling, but so far as the principles will allow the motor is as near perfection as we may reasonably expect.

The question as to whether it is an improvement to increase the number of cylinders to six or eight or even twelve is a debatable one, and even if it is an improvement in smooth running and flexibility, whether the increased first cost is justified has not been demonstrated satisfactorily.

The four-cylinder engine with all its cranks in one plane, its simple cam shaft and block of cylinders, lends itself admirably to the shop practices and processes of to-day for accurate fitting and rapid production. Manufacturers are agreed that the four-cylinder is the preferable motor to make.

However, where cars can be made and sold regardless of first cost, the six-cylinder engine is to be found, proving that it has advantages

appreciated by owners able to pay for it. These advantages are practically perfect balance, even torque and rapid acceleration, and good speed regulation.

To run a good four and then step into a good six and run it over the same route, it must be confessed that these advantages are not very striking.

We could pile on cylinders to the full capacity of the chassis, but there must be a limit where the advantages of additional cylinders are just balanced by the cost and by some disadvantages; and considering the whole question fully, it is almost certain that the four-cylinder is the limit for the vast majority of vehicles.

On the question of small vehicles, the writer's opinion is that the satisfactory small vehicle, one or two seated, has not yet been produced. That is, a car with a minimum of machinery designed for owners of very moderate means who have no desire to climb hills at top speeds or tear along the roads at 30 to 40 miles an hour: a car to climb average gradients at anything between 5 to 10 miles an hour and run on the level at a maximum 16 or 18 miles an hour; a car for people living in towns who wish to take an airing in the country or a pleasant run through the country roads to the seaside and back again. Comfortable seating and leg space and simplicity of machinery should be the first and foremost features.

Such a vehicle might have three wheels only, with no differential gear, and a very simple change speed and reverse gear, for by adopting a four-cylinder engine much of the speed control could be done by throttle if a good automatic carburettor is employed.

Manufacturers seem to be afraid to put upon the market a small vehicle incapable of the higher speeds demanded by a section of the present day would-be small car owners, but it is a mistake, for there is a large number of people who detest this rushing over roads at great speeds, and they know quite well that the most of the cost of the small car is incurred in the endeavour to obtain high speeds, a thing they do not want and will not pay for.

It is the same with all locomotion by land, or sea, or air. Beyond a certain limit in each case, any increase of speed has to be very dearly paid for, in first cost, and in maintenance and fuel, and thirty miles per hour is far above the limit for small vehicles on the ordinary road.

This small car would find a large market. It would be cheap to build and cheap to run, and would, in the oft-quoted words, "fill a long-felt want."

There is just a possibility that the small car for ordinary people will be found in the electric car, also a three-wheeler so that gear may be avoided, all but speed reduction gearing, for the motor should be small and of high speed, with a counter shaft. Ordinary motors are built without much regard to weight, so that a special motor design is required. In this small vehicle the accumulator would be by far the

heaviest item in the total weight, but that would not be a serious item if the car speeds were limited to those quite high enough for a large body of people.

The great simplicity of the mechanism of the electric car, the perfect ease of control, absence of all ignition, carburation, heat, smoke, smell, are great advantages. The driver has only to steer, and has an accelerator pedal for speed, and a pair of brakes of course, hand and foot, no clutch or change speed levers.

As to cost of such a vehicle, that depends greatly on the first cost of the accumulator. And as to cost of running, that depends upon the charges made for filling the accumulator with electrical energy.

The electric is the ideal small car. It may not just at the moment be available, but there is every indication that it is coming and that very soon.

Nothing can more emphatically demonstrate the necessity for a simple form of three-wheeler, two-seated vehicle than the lop-sided, absurd combination of a motor bicycle with a side car. If that sort of thing is tolerable, how much more would a properly designed three-wheeler be appreciated.

A type of motor car which has not been referred to previously is that known as the "petrol electric car." It has not been much used in practice for two reasons—high first cost, and great weight and space of machinery.

The principle of the machine is the use of a petrol motor combined with a dynamo electric generator taking the place of the accumulator on the electric motor car. It carries with it all the many troublesome details of the plain petrol engined car—petrol tank, water cooling, ignition, exhaust silencer, and all the other accessories of the petrol car. It is true it has no gear box, but that is only one feature of any consequence.

Given batteries of any reasonable weight and reliability on an electric motor car, they will on all counts compare very favourably with the petrol engine and dynamo combination.

The place for the petrol engine and dynamo unit is on a foundation in the garage, where it may be used to charge the motor car accumulator.

The questions between sleeve valves and poppet valves and other valves have aroused some controversy. A great many able and experienced engineers hold on to the poppet valve design, while others adhere to the sleeve valve system; some show a tendency towards piston valves.

It must be admitted that the poppet valve has in practice on thousands of engines proved quite satisfactory. It may when badly adjusted make a noise, but when kept in good order the noise is very slight. At high speeds it is not quite so satisfactory, for, as we have already pointed out, it requires great spring power to shut the valve rapidly enough.

On the other hand, the sleeve valve and piston valves are opened and shut positively without any spring action, at all speeds.

An arrangement of piston valves may here be shown in Fig. 249 as an example of that system of construction. At present there is no car made with piston valves on the engines, but many experimental engines have been made with them. The one here shown is by the Albion Company and is perhaps more practicable than some other propositions.

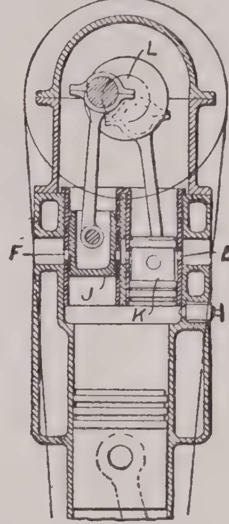


Fig. 249.—Piston Valves.

The inlet and exhaust are controlled by separate trunk piston valves J, K, which work in valve cylinders in the main cylinder head and uncover ports F, E at one end of their stroke. The valve cylinders are parallel with the main cylinder, and are diametrically opposite to one another and equidistant from the axis of the maid cylinder. The plane containing their axes may be inclined to the crank shaft. Both valves, or all the valves in a multi-cylinder engine, are worked by cranks, eccentrics, or cams from a single overhead shaft L.

On the whole, perhaps the single sleeve valve, when new and a good fit, is the better valve, but it remains to be seen how many years it will remain gastight and good fitting. There is also the question of the inertia of the reciprocating sleeve at high speeds and its effects upon the valve operating gear.

A peculiar type of slide valve has been introduced by the German Fischer in an engine. In a plan view, Fig. 250, the cross section through the cylinder is given, the two "new moon" sections in black are sections of the valves which extend from top to bottom of the piston and are worked by cams in the crank casing.

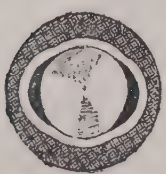


Fig. 250.—Crescent Shaped Valves.

One would imagine it rather a difficult job to machine the cylinder and crescent shaped slide valves gastight, and to keep them gastight in ordinary wear. But one need not be surprised at any proposition in motor engineering. By means of the modern machine shop the fitting and shaping of metals with marvellous accuracy is common practice, and anticipated difficulties seem to disappear.

The cheap American car, made in great numbers on the common American factory system, is bound to make for a change in the motor car industry. A motor car is just one of those engineering products which can be produced cheaply on a large scale of manufacture. We can recall the time when a common bicycle could not be bought for less than £28 to £30; a better machine can be had now for £10.

The cost of a car manufacture is mostly labour. It is hardly worth while using inferior materials, for the small quantity required in

any car makes it difficult to save much in cost by using, say cheaper brass or cheaper steel.

This point was well shown in bicycle making also. A bicycle weighing, say, 30 lb. sold at, say, £20; the high price was said to be due to the very high quality of the materials. Now the common materials would not average over one shilling a lb.; that means 30*s.* for raw material of common stuff.

Suppose, then, in order to get the very best we double the price for material, we get a difference of only 30*s.* on a £20 machine.

We shall in the near future have cars small and large on the market, made of first-class material and well finished from an engineering point of view, at prices far below those ruling now, so that a large class of people who cannot at present purchase cars will find them within their reach.

The growth of the motor car manufacture has been phenomenally rapid, but it will still grow in the direction of meeting the demand for a good serviceable vehicle at a cheap price for ordinary purposes, without great embellishments or great speed capabilities.

Recent exhibitions of motor cars reveal the fact that on its present lines of construction with petrol engines it has reached very near finality. Improvements are now confined almost wholly to minor details.

The great question of the day is the cost of fuel. This has led to increased economy in its use by attention to the carburettor, and a great many new carburation devices (or alleged new ones) have been introduced without much improvement in results.

As matters stand to-day in the motor trade we need not look for radical alterations in designs of the engine and accessories thereof; the large manufacturers have settled down to standardised parts and designs, with factories laid out specially for their continuous reproduction—so that any great innovations are most likely to spring up in new quarters, under the control of new men with fresh capital.

Meanwhile, the choice of a car is a question which the intending purchaser can with difficulty decide. The car is a complex machine with many points upon which only independent unbiased experts can pronounce an opinion, and intending purchasers can readily obtain skilled advice if they have not sufficient mechanical and engineering skill of their own to enable them to judge between different cars.

CHAPTER XI

A POSTSCRIPT ON FUEL

ONE result of war conditions has been a considerable advance in the study of liquid fuels and their application to motors. We are now far less dependent on petrol than we were formerly, and it is found possible to run cars on petrol of a higher specific gravity and of a lower volatility than used to be considered good practice.

To take the fuels in their due order :

Petrols are placed on the market in a variety of grades, with a specific gravity ranging from just below ·700 to a little over ·760. The latter are rather slow to vaporise, and when these are used on many cars it is necessary to start on lighter petrols or benzols until the inlet pipes to the cylinders are sufficiently heated to secure more rapid vaporisation.

Where comparatively slow vaporising liquid fuels are used and it is necessary to start up on more volatile varieties, the best plan is to provide an auxiliary spirit tank, to hold from one pint and a half to three pints. It should be placed handy, so as to require only a short pipe connection with the carburettor, the pipe being fitted with a two-way cock, by which means the lighter fuel can be turned off and the heavier turned on as soon as the engine has thoroughly warmed up. This arrangement is of general application.

The number of artificial fuels has been largely increased, some being for general use, others made up for special types of engines. They usually consist of mixtures of distillates from petroleum, shale, or other oils, and as regards their volatile properties mostly can be classed among the third grade petrols. Therefore, unless specially adapted carburettors, designed to secure thorough atomisation and rapid vaporisation, are used, it is necessary to start up on lighter spirits, if difficulties and delays are to be avoided. But many of them are excellent and real acquisitions, for, while cheaper than the lighter spirits, they give good running results.

It is the benzols, however, that have provided the greatest relief to motorists, and hold out the best promises for the immediate future.

These distillates of coal tar origin, as already stated, are of a higher specific gravity than good petrol, but quite as volatile and, bulk for bulk, will give greater running results, proving especially valuable for hill-climbing and other sustained high-peak requirements. While four years ago they were comparatively scarce and not much cheaper than petrol, the position now is completely changed. By certain modifications

in the processes of manufacturing coal gas and in coking, it has been found possible to produce benzols in abundance at quite moderate prices.

The actual production of benzol in Great Britain by gas companies is between eleven and twelve million gallons annually, and this, by a slight reduction in the calorific value of gas (from 500 to 450 B.Th.U.), could be increased by over forty million gallons. To this has to be added over twenty-one million gallons derived from the coke ovens. Although part of this output is required for dyes and explosives, the total forms a very substantial percentage of the two hundred million gallons of petrol which it is estimated are needed annually in the United Kingdom. But, as will be seen presently, this addition of over sixty million gallons of spirit is of even greater importance than it appears on the surface, because benzol makes it possible to use a large amount of heavier oils in ordinary carburettors.

Benzol is the ideal starter where petrol substitutes and heavy oils are used, for, as it is highly volatile and possesses greater calorific value than petrol, in spite of its heavier specific gravity, a smaller auxiliary tank will do, less spirit being required to get the engine going and thoroughly warmed up. This is a convenience, and means a great saving.

Benzol not only has a higher calorific value than petrol, it has also different chemical reactions. While it is not necessary to go into details as to this, one point does concern many motorists. Some carburettors, notably those from America, are provided with cork instead of metal floats, and are coated with shellac, which is not attacked by petrol, but is stripped off by benzol, causing the cork to become saturated and swollen, thus interfering with carburation. If benzol, or a mixture containing benzol, is used, these cork floats should be coated with a special varnish immune from the corrosive action of benzol.

Mixtures of paraffin and light distillates (both petrols—including gasoline—and benzols) have proved themselves valuable fuels from every point of view. It is impossible to give definite rules as to proportions, because we are dealing with very unstable materials. Paraffin varies widely as to specific gravity, volatility, and calorific value. Both water and solid contents detract from volatility and calorific value, and the latter add to the difficulties of carburation ; more air will be required to prevent sootiness and the formation of after-deposits.

If the paraffin has a low flash point and the lighter spirit is good (benzol, for instance), the mixture may be as much as one-third of paraffin to two-thirds of spirit. With heavier paraffin and inferior spirit, the mixtures should be about one quarter to three quarters.

On these percentages the carburettors will require only slight, if any, adjustment. It should, however, be stated that actual mixtures of heavy oils and light spirits are not desirable. It is the distillates from the mixtures of the two, mixtures containing both fractions, even well down the scale on the heavy oil side, that work well. Mere mixtures of the two are apt to stratify and give carburation trouble.

The heavier the percentage of heavy oils, the more need will there be for carburettor adjustment, the aim in this being to intensify atomisation and to increase volatilisation by pre-heating.

This leads us directly to the use of unadulterated paraffin. In this direction progress has been slow. While all paraffin is now largely used for heavy traffic, on lorries and commercial vehicles, so far it has not proved successful for car work, the ideal vaporiser carburettor being yet undeveloped. Many innovations have been introduced, both in regard to special carburettors and vaporisers. Most success has been secured by fixing a vaporiser tube to the exhaust branch of the carburettor, surrounding it with a flanged casting of copper, cased in a jacket, which enables the utilisation of waste gases from the carburettor. The jacket covers the inlet and exhaust pipes. To the inlet pipe is attached a glass cup containing petrol or benzol for starting up. It drips down and is volatilised by the inrush of air. An extra allowance of air is essential for proper carburation when using heavy oils. But this must not be exaggerated.

Zenith and Solex carburettors are both fitted with bi-fuel adjustments.

Alcohol is receiving renewed attention; experiments are being carried out by the Alcohol Motor Fuel Committee of the Royal Automobile Club, under the direction of Professor H. B. Dixon, F.R.S. But, apart from fiscal difficulties and the burdensome restrictions of the Excise Authorities, the use of all-alcohol fuel means a special type of engine.

Meanwhile successful experiments have been carried out for heavy traffic on mixtures of commercial denaturalised alcohol and benzol. The omnibuses have been run on a mixture of 75 per cent. alcohol and 25 per cent. benzol. As prices rule, this is not a particularly economical fuel. But it is premature to speak authoratively on the subject from the car-owners' point of view. This much, however, may be said. The mixture stands fairly high in the volatile class and also in calorific value. By widening the sources whence alcohol could be distilled and simplifying fiscal control, the supply could be vastly increased and the cost materially reduced. The paramount advantage of alcohol as a fuel is that the sources of supply, being vegetable, are inexhaustible.

We now come to towns' gas for motor propulsion.

Practically the problem divides itself into two parts: namely, (*a*) the use of gas at atmospheric pressure; and (*b*) the use of gas compressed into steel containers.

During the period of active warfare the use of gas at atmospheric pressure found most favour. It is undoubtedly a simple expedient, as it permits of a motor equipped for the purpose to replenish its supply of gas from practically any ordinary gas main.

The container in which the gas is carried consists of a good quality balloon material, usually secured to the roof of the vehicle, but capable of being carried in a trailer. The gas, when stored in such a reservoir, exerts only a very slight pressure above that of the atmosphere (from

5 to 15 tenths of an inch water gauge), but this is of no consequence, since the ordinary petrol engine, capable as it is of creating a suction equal to from one to two pounds per square inch, is easily able to get all the gas it requires. The gas and air are aspirated into the engine cylinder in such proportions as to provide a combustible mixture containing about 45 B.Th.U. per cubic foot. As the result of many observations covering the use of gas in various types of motor vehicles, it may be taken that 250 cubic feet of gas of 500 B.Th.U. per cubic foot will take the place of one gallon of petrol. Several types of air and gas-mixing devices (so-called carburettors) are obtainable which give complete control over the engines under running conditions. But no alterations to engine, and practically none to the curburettor, is necessary. All that is absolutely needed is an admission pipe placed above the throttle.

Although the use of flexible containers was justifiable under war conditions, it is generally agreed that the future development of gas as a motor-car fuel lies in the successful applications of the compressed-gas system. This is now well understood, and it is hoped that the Gas Traction Committee, which has been considering the matter, will soon be able to report favourably. The use of compressed gas brings with it several technical difficulties, such as method of compressing and storing the gas, degree of compression, and means for controlling the pressure at which the gas is released from the storage containers to the engine. Most of these points have been successfully worked out, and it seems that the ultimate development of gas for motor cars will depend entirely upon the relative costs of petrol and gas when prices settle down to a steady state under peace conditions.

The London General Omnibus Company has at least one 'bus operating on gas fuel compressed into containers to about 1,000 pounds per square inch.

In changing over from petrol to gas, a given engine loses about 10 per cent. to 15 per cent. of its power. This, however, is only a temporary difficulty, and can be overcome by increasing the compression pressure, which is perhaps best done by increasing the length of either the piston or the connecting rod.

The use of modern steels for the storage cylinders, reinforced by gun-tape winding, permits of the dead weight being reduced to an amount which does not materially detract from the useful carrying capacity of the vehicle and ensures perfect safety under working conditions.

Regarding the question of weight, it is interesting to bear in mind that with vehicles of the passenger-carrying type, where a certain amount of lighting is necessary, the added weight consequent on the replacement of petrol by gas can be largely compensated for by using the gas for lighting, thereby permitting of the disuse of the heavy electric generating set.

The Smith Suction Gas System (Lieut.-Colonel D. J. Smith, Mechanical Transport Section, Royal Army Service Corps) is designed for lorries

and other heavy vehicles, but may have wider application. The plant (weighing 230 lb. for a two-ton lorry) consists of : (1) producer, (2) feed water and gas cooler, (3) gas scrubber. The fuel used is anthracite or similar material. The producer is worked from the engine of the lorry, the fuel being automatically fed by a worm conveyor as it is required, the fire-bars rocked to remove ash and the water pumped to the feed-water heater and boiler. When once started, the whole is automatic. By the suction of the engine air is drawn over the surface of the water in the boiler, becomes saturated with steam, and passes through a pipe to the ash-pan, there rising through the fire-bars and burning fuel, thereby taking up gas. Thence the gas passes on to the feed heater and the scrubber, where it is washed and passed on to the engine cylinders. The producer is placed on the dashboard on one side of the bonnet and the feed heater and scrubber on the other, while the control levers, gauges, etc., are placed within easy reach of the driver. The rate of consumption of anthracite is 0·4 lb. per ton mile. It appears probable that if the plant was used as a stationary outfit, the gas could be produced for filling balloon or other containers for cars.

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